THE HYGIENE OF SCHOOLS & SCHOLARS.

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RALPH, HOLLAND & Co.

THE HYGIENE
OF
SCHOOLS AND SCHOLARS.

FOR TEACHERS AND PARENTS.

BY

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London:
RALPH, HOLLAND & CO.,
TEMPLE CHAMBERS, E.C.

1902.

PREFACE.

It has often struck me in the course of my duty as a Medical Officer of Health in town and country, how deep seated is the belief that the ills which sanitary officers endeavour to remove are part of the dispensation of Providence. If we can teach the young that 90 per cent. of the illness and trouble in this world is due to man's own fault, mostly carelessness and selfishness, we shall effect great progress in sanitary advance. There are doubtless many books similar in scope to this little handbook, but with such an inert resisting mass to overcome, the teaching herein set forth can hardly be overdone.

I have endeavoured to arrange the book round the scholar's body to begin with, roughly entering on the Anatomy and Physiology of the different parts. With this general knowledge of the child's physique, it should be easier to understand the effect of study and play upon the organs and the body as a whole.

The subject of Ventilation and Warming is treated first from the theoretical point of view, and then in its application to building, etc.

The last chapter is devoted to School Accidents.

I do not lay any claim to originality in this little book, it being largely a compilation from the works of many authors. It has been my endeavour to simplify, as far

as possible, the descriptions so that they may be clearly understood without any special knowledge of the sciences on which Hygiene is founded.

It is quite impossible to quote all the authorities that must be consulted in even a small work like the present, but I have to thank Messrs. Geo. M. Hammer & Co., School Furnishers, by whose courtesy we are enabled to reproduce the diagrams in Chapter V.; and also the St. John Ambulance Association, with whose kind permission we use the illustrations in Chapter XI.

I have also to thank Messrs. Curry and Paxton, Opticians, for the use of their Table of Types, facing Page 35.

H. B. C.

Kingston.

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CHAPTER XI.

CHAPTER I.

The Head.—Complexion.—Blood corpuscles.—Town dwellers and fresh air.—Dimensions of the head.—The expression. The Mouth and Nose.—Cold in the head.—Causes and prevention.—Exposure to wind and fog.—Adenoids. The Ears.—Malformations.—The internal ear.—Hearing.—Earache and discharges. The Brain.—Nerve cells and nerve fibres.—Afferent and efferent nerves.—Sense stimulation.—Spontaneous movements.—Voluntary and involuntary movements.—Production of mental aptitude.

Physical and mental development in the scholar are so closely related that a general survey of the human body is necessary to their proper consideration. The different parts are so intimately connected that undue attention to symptoms pointing to irregularities may easily prove misleading unless considered as a whole and in relation to the conditions existing in health.

The Head.—The head should be well balanced and the features symmetrical. In children, plump cheeks, with a smooth skin and absence of pimples, should be looked for. The complexion varies according to the amount of pigment in the skin, from fair to dark, but should be reddish in good health, pink in fair children and a ruddy brown in those of darker complexion. The lips and the inner surfaces of the eyelids should never be pale, but the latter should not be unduly injected. Children of southern races are sometimes pale though healthy. The red colour is due to the red blood

corpuscles. These are microscopic discs observed in the blood, $\frac{1}{3200}$ of an inch in diameter, and their function is to convey oxygen to the tissues of the body for the maintenance of life. Their number varies, but when greatly diminished there is impairment of health.

Town dwellers suffer very much from anæmia, or pallor, the result of indoor life and absence of sunlight. Much can be done, even in town life, by exercise in the open air and proper ventilation of living-rooms and bedrooms. A child should be taught to sleep with the windows open all the year round. The clothing of the child should be warm, and if plenty of open-air exercise is taken there is increased physical tone, and therefore lessened danger even when entering living rooms overcrowded and unduly heated. Colds are rarely contracted by persons living in the open air, except from patients already suffering from catarrh, with whom they are unavoidably thrown in contact in crowded rooms, railway carriages, etc.

Measurements may be taken of the Head: (1) the horizontal circumference; (2) the transverse arch, from ear-opening to ear-opening; (3) from the bridge of the nose to the prominence felt just above the nape of the neck (occipital protuberance). In nervous children these measurements may be compared from time to time. A circumference of between 20 in. and 22 in. is normal for school children.

Observe the profile, and note the curve of the top of the head; whether the forehead is prominent or receding; the shape of the nose, whether with marked bony bridge or sunken; the mouth, whether large, small, or well

shaped; and the chin, whether strongly shaped or receding. Some of these particularities have a marked effect on physical health, whilst others may be indicative of mental deficiency, or the reverse.

Undue prominence of the upper part of the forehead, giving the appearance of a large cranium, may be due to rickets, and not to mental development. A small cranium may go with fair mental development; but in such cases headaches are common. The head should be held erect. In nervous girls it is often held on one side, and in cases of nervous weakness it may be bowed.

A healthy, normal child has a calm expression. There should be neither twitching of mouth, nor continual grin. Wrinkling or puckering of the forehead is out of the normal. It may be seen, causing horizontal lines in deficient intellectuality, or by drawing of the eyebrows together, so as to form vertical lines, in over-stress of mental action.

The Mouth and Nose.—A small, narrow mouth may interfere with proper breathing, whilst an unduly large mouth with loose lips may accompany imperfect mental development. Cleft palate may, or may not, accompany deficient intellect. The teeth should be regular and the presence of *caries* (decay) may have marked effect on health by interference with mastication, leading on to digestive troubles.

On opening the mouth, the condition of the tongue should be noted. It should be evenly red, without fissures or sores. The insides of the lips and cheeks should be even of surface, without sores or irregularities.

Such irregularities may be due to jagged teeth, dyspeptic troubles, or signs of specific diseases. The mucous membrane covering these surfaces is well supplied with blood vessels, and is moistened by a clear fluid called the saliva. This may become excessive, thickened, or sticky, owing to derangements in teeth, and then becomes a suitable soil for the cultivation of disease germs, which, in a state of health would find no lodgment.

Children should be taught to thoroughly masticate their food, so that it may be well chewed and mixed with saliva before being swallowed. It is then in a condition more easy of digestion; but, in addition, the use of the teeth thoroughly in this way is beneficial to the teeth themselves, the movement of the coarser particles over and round about the teeth having a cleansing effect upon them, whilst the increased flow of saliva washes away particles of food from the teeth, which, if not removed, may tend to set up decay.

At the back of the mouth is seen a fleshy arch, the *fauces*, leading from the mouth to the throat. On either side of this are the *tonsils*, which are normally slightly rounded bodies lying between the pillars of the fauces, whilst from the centre hangs a fleshy pendant called the *uvula*. If the tonsils are enlarged, or covered with small sores, or grey-looking particles, disease is probably present. Behind the root of the tongue is the *larynx*, where the voice is produced, and behind this is the *gullet*. On either side of the upper part of the throat, behind and above the tonsils, are the small openings of the *Eustachian Tubes*, leading to the middle ears.

Behind and above the fauces, are the posterior or

internal openings of the nostrils, through which we are intended to breathe whilst keeping the mouth closed. The nose is therefore of great importance in respiration. From the external, or anterior, openings of the nostrils to the posterior openings is a large chamber divided up by thin plates of bone, well covered with blood vessels, etc., so that the air, instead of rushing straight through the nose, as it would do through a tube, is directed backwards and forwards, and from side to side, like a person entering a maze, thus being brought into contact with a large amount of surface in a restricted space. The inner surfaces of the chambers of the nose are covered with mucous membrane, well supplied with blood vessels, so that the air becomes warmed and moistened before going down into the lungs, instead of entering at the temperature of the atmosphere, as it would do if taken in by the mouth. Not only so, but particles of soot, etc., adhere to the surfaces, and are worked outwards by certain minute projections from the mucous membrane, called *cilia*.

Blind, and deaf and dumb, persons sometimes have the sense of smell sufficiently increased to detect persons and things by their odours.

Discharges from the nose are of great importance, as they frequently continue after supposed recovery from scarlet fever and diphtheria, and are potent means of spreading infection.

Catarrh of the nose, or cold in the head, may be an early symptom of measles. Cold in the head results from a general chill to the system, which lowers the general vitality and renders the membranes of the nose,

etc., liable to be attacked by germs coming from other persons suffering from catarrh. In robust health the membranes of the air passages have sufficient resistant force to throw off the poison germ, so that it cannot take root and germinate. This poison is most prevalent in crowded places, where persons with the disease are congregated, and it is therefore necessary, under like circumstances, to empty class-rooms frequently, so that a full current of air may be passed through them and the air revivified with oxygen to kill the poisonous germs.

To preserve the mucous membrane from catching cold, it is necessary to bathe it frequently with pure fresh air. Absolutely pure air is only found on mountain tops, or mid-ocean; but even the air in open places in cities is sufficiently pure to give tone to the air passages and render them fairly resistant to germs. The air of the smallest lane, or alley, is purer than in crowded rooms, churches, theatres, etc., in which the air is laden with decaying organic matter from the lungs and skin, dust, dirt, and germs. Sudden exposure to cold from a heated room is inadvisable and sometimes dangerous. The temperature of the room should be kept at about 60°, and if there is cold wind or a very low temperature a short, but rapid, exercise sufficient to start a vigorous action of the heart should be taken before going into the cold air.

The opening of the windows to revivify the impure air of crowded rooms, whilst they are temporarily emptied, serves also to lower the temperature of the room, so that children coming in from the fresh air should not suddenly enter an overheated room, full of organic

particles and germs, which may be vigorously inhaled owing to quickened breathing and the quickening of the heart's action due to exercise.

East wind may be dangerous to any other than very vigorous children, but all exposed to it should be well clad and kept in rapid exercise. For school exercises, as much shelter as possible from the wind should be secured, and care should be taken to see that the children are not kept longer at the exercise than is necessary to set the circulation going thoroughly. Anything like fatigue may be specially dangerous with cold wind.

Fog, especially London fog, is dangerous for delicate or poorly nourished children. Well fed children properly clothed may be sent out into the London parks even in foggy weather, and will probably suffer less from "colds" than those who are kept indoors.

The posterior nostrils are sometimes obstructed with fleshy growths called *adenoids*, or by enlarged tonsils interfering with respiration. The child keeps the mouth open, and the voice is harsh and thickened. M's and N's are changed into B's and D's. There may be "cold in the head," headache, or shortwindedness. If not attended to, the respiration, by being impeded, prevents proper expansion of the chest and lungs, and thus the blood does not get properly oxygenated, causing general debility, ill nutrition of the brain, etc. Growths of this kind should be attended to in early life, and the teacher must be on the look-out for thick utterance and discharges from the nose, so that notice may be sent to the parent and the child taken to a doctor for treatment.

The Ears and Hearing.—The ears should be alike, well formed and symmetrical. There should not be over-prominence with great convexity behind, and the pleats should be well marked and regular. Malformations of the ears are common enough in persons of weak intellect.

The opening of the ear on either side is the orifice of a short tube about 1¼ inches in length, which is closed internally by the membrane of the drum of the ear. The bottom of the tube is longer than the roof, so that the membrane of the drum closes the tube in a slanting direction. This tube is lined with skin having a few hairs projecting into it, and it is liable to be affected with skin diseases.

Inside the membrane is the drum of the ear, containing three little bones called *ossicles*, which, being attached to the membrane, act as levers, and convey the impressions of the sound waves, coming through the air-tube on to the membrane to the *labyrinth*, or internal ear, where the sounds are registered and sent on to the brain.

The *Eustachian Tube* extends from the drum to the upper part of the throat. It is not an open tube, except during the act of swallowing, when air is allowed to enter the drum or middle ear. If this tube is occluded by catarrh or pressure from enlarged tonsils or adenoids, hearing is interfered with, and singing in ears—*tinnitus aurium*—with deafness is caused owing to the air in the drum being more rarified than the external air. Hearing is re-established as soon as the Eustachian Tube is cleared and fresh air enters.

In order to test hearing, a watch may be used. A number of persons with good hearing should be taken,

and the watch held at measured distances from the ear, so that the distance of hearing for that particular watch should be gauged. The person to be tested should not see the watch, and the opening of the opposite ear tube should be closed. The watch should be suspended by the handle on a level with the ear.

The teacher should test the power of the voice in the school-room by placing a pupil at a distance of about 20 ft. with his back to the teacher, to avoid all chance of lip reading, and the teacher should then speak in his ordinary voice advancing a step or two till the spoken words are distinctly heard. The teacher will then know at what distance he should stand in order to be distinctly heard by the class.

General noises such as are present in a school-room have no prejudicial effect upon hearing. *Earache* is frequent in children whilst cutting their second teeth. It is caused in these circumstances by chill, and the patient should be kept quiet in an equable temperature till well.

Discharges from the ear tubes are very common after such diseases as Diphtheria and Scarlet Fever, and whilst they continue the patients are liable to spread infection, as the disease germs are usually present in these discharges. Such discharges have also an offensive smell. The discharge may be thin and glairy, or yellow and thick, and may also be streaked with blood. If unattended to, the discharge may spread to the inner ear and deafness be caused, or the bones may become diseased and abscess of the brain set up, causing death. All children with such discharges should be placed under the care of a medical man.

The Brain.—The brain is protected from injury from without by the skull and within that by delicate membranes. It consists of the *cerebrum*, the larger and upper portion, and the *cerebellum*. It is in direct connection with the *spinal marrow*, or spinal cord, which extends the whole length of the spine. The cerebrum is divided into right and left *hemispheres* and into *lobes*. The brain matter is arranged in convolutions and consists of white and grey matter. The more important structures are in the central portion, in direct continuation with the spinal cord. Portions of the outer portion of the brain substance have been entirely removed without causing death. For our purpose we may regard the brain as consisting essentially of *nerve cells* and *nerve fibres*. The nerve fibres are of two kinds, *afferent* and *efferent*, and there are also fibres connecting the different cells. The afferent nerves extend from the organs of special sense such as the eye, ear, etc., to the nerve cells, whilst the efferent nerves act from the nerve cells to the various organs, and set up the action demanded by the organ of special sense. The nerve cells act much in the same way as a galvanic battery and become in time exhausted and require replenishing. This can only be accomplished by rest and a fresh supply of oxygen being conveyed to them by the blood. If an apple is placed in front of a young child, he looks at it; the impression on the eye is then taken by the afferent nerve to the brain, and from the brain cell by the efferent nerve to the muscles of the hand and arm, which is extended to seize the fruit. Brains must not only be fed with oxygen, but by education, for the nerve cells increase by stimulation through the

organs of sense. The movements in infants are spontaneous and they continue to be so to a considerable extent up to school age. The movements of young children should not be unduly controlled in the progress of education. In young children, eye movements, however, are not very extensive and training should be given to their proper movement. The movements controlled from the nervous centres are some voluntary and some involuntary. The involuntary movements are those concerned in the circulation, respiration, etc.

Much may be learnt from the study of a sleeping child. "The body is quiet; if you raise his hand gently, it falls lifeless—no muscular energy is being expended. The body is motionless in full sleep, except for the movements of breathing, which are quiet, regular, and uniform. If sleep is full and complete, on raising the eyelids, the pupils are seen to be very small or contracted. The body and brain are in complete rest; no currents are generated by the brain in perfect, dreamless sleep. You then hear sounds in the house, which send currents from the child's ear to his brain; we then see movements of his limbs. As sounds grow stronger in the house and light comes in at the windows, the movements increase and the eyelids open. The child wakes and sits up, hence currents are now passing from the brain to the muscles. Before school he is all movement owing to spontaneous brain activity. Spontaneous brain action is the basis on which you work in producing mental aptitude; it must be co-ordinated or regulated, but not so as to destroy spontaneity."—WARNER.

CHAPTER II.

THE EYES.—General appearance.—Movement of Eyes equal and free, but not excessive.—Structure of the Eyes. —Sclerotic.—Cornea. —Vitreous and aqueous humours.— The Lens: convex; changeable focus.—Iris: Pupil; the Retina.—The Normal Eye.—Parallel rays of light focussed on the visual spot.—Binocular Vision.—The Flat Eye.—Parallel rays focussed behind the visual spot. —Alteration in the convexity of the Lens.—The ciliary muscle: headache, blinking, twitching.—Remedy by convex glasses.—The Long Eye.—Later period of school life.—Parallel rays in front of visual spot.—Concave glasses.—Book-reading easy.—Wall-reading difficult—Cause, continued study of small objects.—Long hours of study.—Home lessons injurious.—Astigmatism: difficulty of seeing lines.—Type used in printing.—Disadvantages of glazed or thin paper.—Names of Types: Solid, Thin-leaded, Leaded.—Faults in the shape of the type letters: German type.—Testing the Eyesight: Cards marked with letters and distances at which they should be seen.—Where to place the child to examine.—Registering defects.

The Eyes.—The eyes should be bright and clear. The whites should not be tinged red. There should not be sores, or styes on the eyelids, and the eyelashes should not fall out. The eyes should be of equal size, and the eyelids should rise and fall together. The eyes should together follow an object moved about, two or three feet in front of the face. When looking at near objects, about ten inches, the eyes turn equally but slightly towards one another. Horizontal movements are made without much movement of the eyelids, but vertical movements are accompanied by raising and

lowering of the eyelids, or if necessary of the head itself. Unnecessary movement of the head shows an absence of eye training and is common in very young children. The movements of the eyeball are affected by small muscles (Fig. 1, 8) attached to the outside of the eyeball and the walls of the *orbit*.

Excessive and unnecessary movement of the eyes or eyelids may be a sign of nervous weakness. The eye is a very complicated structure easily deranged, and with little power of re-adjustment. In education the first object should be to train and care for the eye so as to

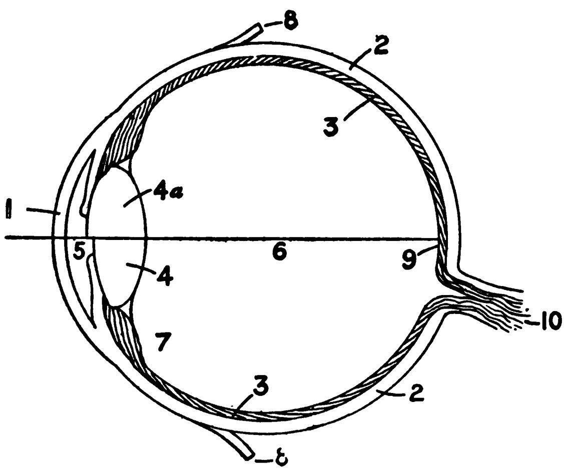

Fig. 1.—The Eye.

improve it and make it a valuable commercial asset for the life long use of its owner, but, in practice, education has proved a source of injury to the eye, and it therefore becomes imperative that the teacher, as representing the State, should see that this state of misuse should cease

and that, at the least, care should be taken that no injury should be done to the eye during school life.

The eye (Fig. 1) consists of a globe formed by a tough opaque membrane called the *sclerotic* (2) and containing a jelly like transparent medium called the *vitreous humour* (6). At the front part of this globe the sclerotic merges into a clear transparent watch-glass-like modification of the wall of the globe called the *cornea* (1). The cornea has a fixed but different curvature to the sclerotic. Behind the cornea and in front of the vitreous humour is the *crystalline lens* (4), a resilient body supported in position by the suspensory ligament and in intimate connection with the choroid. The lens is convex and its curvature can be changed (4*a*), and its form altered by the action of the ciliary muscles (7) which lie behind the sclerotic like flat circular rays beyond the circumference of the lens. In the space between the lens and cornea is the *aqueous humour* (5).

In front of the lens is the iris. This is a circular curtain with a hole in the centre called the *pupil*, for the transmission of light through the lens and the vitreous humour, to form a picture on the *retina* (9), a sensitive registering arrangement of nerve-filaments, on the inner side of the sclerotic opposite the opening. The colour of the iris depends upon the presence of pigment cells. These are absent in the pink-eyed albino, but become more and more numerous for blue, hazel, and brown, or black, eyes. When light is strong the circular muscular fibres cause the pupil to contract to a pin point, and when light is dull the radiating fibres cause it to dilate so that more light is admitted to the retina. The

back of the iris is well supplied with pigment cells. At its circumference the iris is intimately connected with the *choroid* (3), a vascular lining membrane to the eyeball, which is continuous with, but distinct from, the sensitive retina at the back of the vitreous humour. The dark lining of choroid and iris serves to absorb superfluous rays of light so that all rays may be concentrated on the retina.

The *retina* is a delicate nervous membrane consisting of two varieties of nerve structures, called *rods and cones*, from which proceed nerve filaments conveying the impressions received from the light rays to the brain centre. This membrane is a very delicate structure in seven layers about $\frac{1}{80}$ inch thick. The central portion is about half that thickness, and is the most sensitive to light. It is to the perfection, or imperfection, of eyesight in the central point that all references to standards of vision are made. The outer parts of the retina enable us to see large objects, and by this means we are able to walk safely along a road whilst the central point of vision is occupied with reading a letter or book. The *optic nerve* (10) enters the eyeball in the outer part of the retina.

Normal Vision.—The normal eye is known as the emmetropic eye. In this eye the rays of light coming from a distance as parallel rays, are focussed by the convex crystalline lens to converge at the visual point of the retina so as to form a perfect picture. Rays proceeding from a near object are divergent, and these must be made to converge to the visual point of the retina by the convex crystalline lens. This convexity is, however, fitted for converging the parallel rays coming from a distance, and in order to converge the near divergent

rays the convexity of the lens must be increased. This is effected by the contraction of the ciliary muscles drawing the choroid forward and lessening the strain upon the suspensory ligament of the lens. The lens being of a resilient nature in construction springs forward and increases the convexity, more particularly that of the anterior surface (Fig. 1, 4*a*).

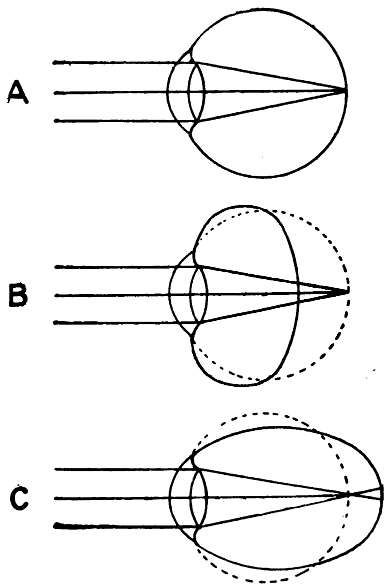

Fig. 2.—(A) The Normal Eye; (B) the Hypermetropic Eye; (C) the Myopic Eye.

Binocular Vision.—It must be remembered that proper vision is binocular, that is, both eyes are used to see one object. The optic nerve is peculiar in its construction for this reason. Thus the fibres rising on either side of the brain supply not only the eye of the same side, but send fibres across through the optic commissure to the eye of the opposite side. Fibres also pass through this commissure from one side of the brain to the other, and from one retina to the other. From Fig. 3 it is apparent that an object nearer the eye, say at 2 feet, appears larger than the same object at 4 feet, and it may

therefore be asked why it should not be looked at 2 feet away instead of 4 feet. The reason is that at four feet away there is less necessity for the eyeballs to converge in order to see a single picture of the object, and therefore less need to bring the action of the ciliary muscle into play than at two feet; also as the object is seen by both eyes, both ciliary muscles would be brought into use and made tired. As this muscle very readily becomes fatigued it is better to look at the object at a

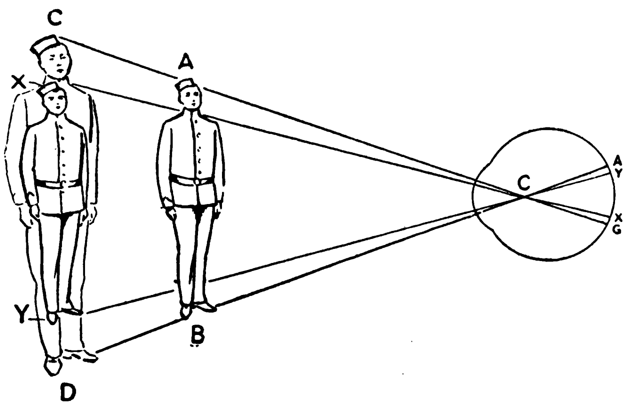

Fig. 3.—Why an Object appears larger when near the Eye.

greater distance, as less convergence of the rays is needed to focus it on the retina, and there is consequently less fatigue of the muscles. When the child tires from looking at the object, the picture on the retina becomes blurred because—the focus not being exactly maintained—instead of both eyes seeing the object as one, there is a little irregularity, and the object appears with a ghost-like double beside it. As the fatigue increases, the error in

vision increases, and under continued exertion the eyeball becomes lengthened and short sight is induced.

Hypermetropia.—At birth the eye is always flat. It is, in fact, an immature eye, and under favourable circumstances tends to become a normal eye at manhood. Hill tribes are usually found with normal sight, but in school children in civilized countries the normal eye has become abnormal from its rarity. In the junior classes 88 per cent. of the eyes of the children are hypermetropic, and a little over 4 per cent. are myopic, but in the senior classes hypermetropia is reduced to 67 per cent., and myopia increased to 19 per cent. Normal vision is respectlvely 8 per cent. and 14 per cent. In hypermetropia, parallel rays from the distant point of vision converge from the crystalline lens to a point beyond the retina, so that the picture instead of being focussed to a point is focussed to a circular disc and is consequently blurred, owing to the flatness of the eye (Fig. 2 B). The ciliary muscle in consequence is brought into action and the convexity of the lens increased so as to bring the long distance parallel rays to a focus point on the retina. This action of the ciliary muscle is, however, intended to be used for near objects, and it is clear that if used in addition for distant objects it must become overworked. The ciliary muscle is very readily overstrained and then does not respond quickly when required to change the focus. Overstrain causes blinking and winking; especially on exposure to light. The eyes ache or there may be neuralgia which is perhaps attributed to some other cause, and may come on hours after the strain; twitch-

ings of the eyelids, sometimes extending to other muscles of the face and resembling St. Vitus's dance. The eyes are congested and red, and watering. Styes are common and the eyelids stick together in the morning. In bad cases there may be squint, dizziness and nausea, for which skilled aid should be called in.

In order to remedy the defect of the flat eye, a convex glass is placed in front of the eye, of such a convexity that the parallel rays from the distant visual point are focussed correctly on the retina without bringing the ciliary muscle into use to increase the convexity of the

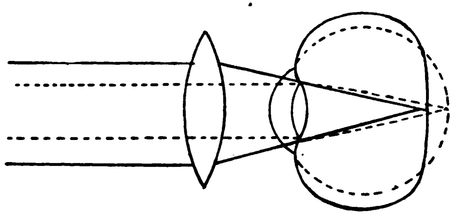

Fig. 4.—The Use of Spectacles for Longsightedness.

lens (Fig. 4). Thus the flat eye is made equal to a normal eye for distant sight, and the accommodation of the eye by the action of the ciliary muscles on the lens is left unused except for the adjustment of near objects for which it is intended.

Children do not call attention to defects unless pain is caused, as they have no standard of vision by which they can estimate errors. In addition to the ill effects arising and already mentioned, it will be noted that flat-eyed children begin to read well, but as the ciliary muscles tire the child makes mistakes. It then shuts the eyes, rubs them and tries to read again, but

quickly tires. Such children are also slow in learning to read.

Hypermetropia may be mistaken for myopia because the child brings the book nearer the eyes to read. This is done partly because spasm of the ciliary muscles is caused by the effort to see small objects at a moderate distance, and because by so doing the image appears larger and this compensates for the indistinctions. The child usually sees worse in the morning, as the ciliary muscles have not got into proper working trim.

Proper glasses effect a remedy in most cases, but in a certain .number it is necessary to leave off lessons and keep the child at play in the open air for a lengthened period.

Myopia.—The elongated eye, or shortsighted eye is chiefly found in the later periods of school life. In this eye, the eyeball being lengthened, the parallel rays are focussed to a point in front of the retina from which they diverge so as to fall on the point of sight

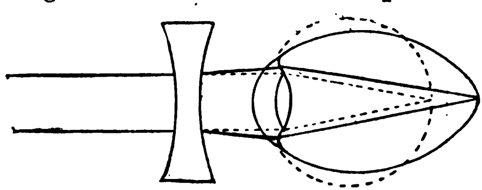

Fig. 5.—The Use of Spectacles for Shortsightedness.

as a disc instead of a point, and thus give a blurred picture. Rays from near objects being divergent, these eyes can focus objects up to a given distance without exertion, but not beyond (Fig. 6).

In order to make the parallel rays focus without exertion,

concave glasses are placed in front of the eye, by which these rays are made slightly divergent as they fall on the convex crystalline lens, and are then less convergent as they pass on from the lens, so that they focus to a point on the retina behind those from parallel rays (Fig. 5).

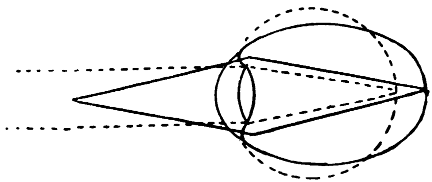

Fig. 6.—Divergent Rays in Myopic Eye.

Short-sight or myopia is caused by the continued study of small objects by persons with eyes having a weakened enclosing case. This may be moderate, in which case no harm results, or excessive, such as when bulging of the sclerotic increases the length of the eye and still further increases the myopia.

Children should be suspected to be myopic when they read well from books through the book being adjusted to the right focus, but not from the blackboard or

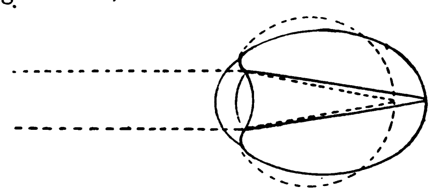

Fig 7.—Parallel Rays in Myopic Eye.

diagrams on the wall, which being fixed, the parallel rays are focussed in front of the retina by the myopic eye. Natural objects may easily be distinguished by

persons who only see distant objects slightly blurred, as they can readily compare a blurred haystack with a blurred house. Some letters may even be distinguished if they are of markedly different shape. It is therefore necessary to test the eyesight for certain definite objects at certain definite distances. A slight amount of myopia may not be any disadvantage for town life, but is a bar to employment in the navy and to a lesser degree in the army and mercantile marine.

It has been shown before that children are born with flat eyes or hypermetropia. These eyes when disposed to myopia, gradually pass from the flat to the elongated type till they reach a certain point when the progression may stop and a serviceable eye result.

In other cases the change is not gradual, but by fits and starts, probably owing to unsuitable surroundings and to straining of the eyes at small objects. The eyes may progress at different rates so that one eye only is habitually in use, and the other assumes an excessive squint, making a very ugly deformity. These cases may cease to progress after manhood is reached, but in extreme cases continue to get worse into middle life.

It is thus clear that short sight is greatly aggravated by the usual methods of education. It arises in children with predisposition, but also in those suffering from general weakness, either physical or nervous, and particularly in those convalescing from febrile diseases. Fever hospitals should not, therefore, have books with small print for the amusement of the inmates.

We will proceed to deal with the chief causes of aggravation of this disorder. Reading and writing cause

physical exertion in the accommodation of the eye, and should not be continued for long periods without intervals of rest for recovery of tone in the ciliary muscles, which have been shown to be particularly liable to fatigue. Tasks should not be too long. The change from a study of near objects to distant objects should not be immediate, but separated by an interval of exercise, singing, etc.

Impositions of writing should be condemned, and writing exercises should be limited, as they are only useful for classification, and do not assist the memory as much as is often supposed.

Home lessons may be useful to the teacher in working the classes, but they are extremely prejudicial to the scholar. In the evening the child is tired and sleepy, and in the majority of homes there are not proper desks, proper light, nor proper quiet for doing the work. The eye is almost first to show signs of desire for sleep, and it is clear that under such conditions it is not in a fit state to be used.

Astigmatism.—This form of eye disease usually accompanies hypermetropia and myopia and is caused by variations in the curvature of the cornea, or the structure of the lens. It is sometimes caused by ulcers, etc., of the cornea.

There is usually difficulty of distant vision. There may be headache, and sometimes the patient sees better by putting his head on one side so that some of the rays of light are cut off by the bridge of the nose. The tests usually made use of are radiating lines, some of which will be blurred if this condition exists. The condition

may vary in the two eyes. Special cylindrical glasses have to be used to correct the errors.

Printing Types.—The type used in printing is often harmful to the sight. In newspapers it is frequently indistinct and on thin paper, showing signs of the print on the back of the sheet. In books the paper is glazed and shiny, reflecting light and making the print look faint. A list of the names of the different type, with specimens of the size, will be found useful.

Name.	Height of Letters.
Brilliant	0·75 mm.
Pearl	1·0
Minion	1·25
Bourgeois	1·5
Small Pica	1·75
Pica	2·0
English	2·5

It is evident that Bourgeois is the smallest that should be used constantly, whilst for school books Pica for older children and English for the beginners is absolutely necessary, as the book should be seen at least 24 inches from the face. The book should not be held in the hand but propped up on the desk in front whilst the scholar sits leaning back, but straight on the seat.

p, **q**, **d**, are legible, but **h** is like **b**, making easy recognition difficult. H and U are too much alike, the cross line being very thin. H U are much easier to distinguish. The time of exposure for the recognition of a letter varies from ten to fifty one-thousandths of a second for different letters.

If the letters are too close together, the rapidity with which they have to be received on the retina causes some blurring of the outline, consequently the words should be well spaced from one another, and an arrangement, which is known as "leading," made use of to separate the lines. The same sentence is shown solid, thin leaded, and double leaded in different types.

PICA.

"I do not know what I may appear to the world, but to myself I seem to have been only a boy playing on the seashore, and diverting myself now and then finding a smoother pebble, or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

"I do not know what I may appear to the world, but to myself I seem to have been only a boy playing on the seashore, and diverting myself now and then finding a smoother pebble, or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

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BOURGEOIS.

"I do not know what I may appear to the world, but to myself I seem to have been only a boy playing on the sea shore, and diverting myself now and then finding a smoother pebble, or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

"I do not know what I may appear to the world, but to myself I seem to have been only a boy playing on the sea shore, and diverting myself now and then finding a smoother pebble, or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

"I do not know what I may appear to the world, but to myself I seem to have been only a boy playing on the sea shore, and diverting myself now and then finding a smoother pebble, or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

MINION.

"I do not know what I may appear to the world, but to myself I seem to have been only a boy playing on the seashore, and diverting myself now and then finding a smoother pebble, or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

"I do not know what I may appear to the world, but to myself I seem to have been only a boy playing on the seashore, and diverting myself now and then finding a smoother pebble, or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

"I do not know what I may appear to the world, but to myself I seem to have been only a boy playing on the seashore, and diverting myself now and then finding a smoother pebble, or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

The lines of a book should not be too long, so that if a book is wide it is better divided into two columns for easy reading.

Paragraphs should also be short, and the Bible printed in good type, being in verses, is easy to read. Dialogue is also a form that does not tire the eyes.

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The printed letters themselves should be plain and simple with the spaces well marked. All kinds of unnecessary finials, or seriphs, and extreme contrast between the up and down strokes should be avoided.

German type is especially trying to the eyes and is gradually ceasing to be used in Germany, more especially in works of a scientific nature.

Maps are best studied from large clearly printed sheets hanging on the walls. Small maps crowded with detail are very trying to the eyes.

Testing the Eyesight.—The sight of school children should be tested twice yearly. This is done by the use of types specially printed and marked with a figure indicating the number of metres at which it should be seen. Taking the type 6 and placing the child at six metres distance, if it is read distinctly the sight may be uniformly expressed by placing the distance as the numerator and the type read as the denominator of a fraction thus, $\frac{6}{6}$ or normal vision, but if at six metres the type eighteen is the smallest seen distinctly, the vision is expressed as $\frac{6}{18}$ or $\frac{1}{3}$ of the normal.

The child should be placed so that the light falls on the types and does not dazzle the child's eyes. A variety of tests should be kept so that the children should not learn the order of the letters. Children should generally see better than the standard, but with young children allowance must be made for want of familiarity with the letters. Each eye should be examined separately by covering one eye with a card. If any defect is discovered the parents should be informed so that means may be taken to obtain proper spectacles.

CHAPTER III.

THE NECK AND THROAT.—Glandular swellings.—The Larynx: A triangular-shaped box.—Voice production.—Vocal chords: bass and soprano.—Movement of lips, tongue, etc., in articulate speech.—Voice in school.—Proper articulation: Position of the Body.—Tight clothing, corsets, belts, etc., interfere with clear speech.—In voice production the extremities are fixed and the chest in movement.—Singing should not accompany general exercise.—Hoarseness: Mucus on the vocal chords.—Clergyman's sore throat.—Bad speakers trying to speak loudly.—Stammering: Spasmodic contraction of diaphragm; more common in boys.—Thick voice.—Adenoids.—Whispering.—Speech without voice.—Voice changes more marked and later in boys. THE CHEST.—Respiration.—Expiration slightly longer than inspiration.—Measurements of the Chest: half the height of body; greater in country public schools.—Inspiration increases size of Chest.—Action of the diaphragm.—The Lungs.—Bronchi.—Air cells.—Oxidation of air.—Respiratory capacity.—The Heart.—Pulse beat 90 at six years, decreasing with age. THE SPINE.—Its curves; its construction; its muscles.—Unsuitable postures cause curvature.—Constitutional and local causes.—Position of children in standing: legs apart; military stand easy.—Real cause of deformity.—Necessity for physical exercise.—Tone to the muscles.—Increased physical capacity entailing increased mental power.

The Neck and Throat.—The neck is comparatively small in children. Particular attention should be paid to any general fulness (particularly under the jaws), or swellings of the glands of the neck, as these become enlarged in many diseases, especially the ordinary infectious disorders; but small chains of swollen glands sometimes exist in the neck as a consequence of pediculi

(lice) in the head. The swelling of the glands may also be due to scrofula.

In the front part of the neck the larynx or voice organ is situated. This is commonly called Adam's apple, but it only becomes prominent in men at puberty. It is a triangular-shaped chamber with hard cartilaginous walls, the angle pointing forward. The vocal chords are folds of membrane at the upper part of the larynx. When at rest the opening is triangular with the apex in front and air passes in and out of the lungs without sound being produced. These chords can be tightened by the action of certain muscles, and they are then brought closer together, when the air passing between them causes vibrations which produce notes varying from low to high according to the tightness with which they are stretched. The amount of tension for each particular person varies, and notes are caused by the number of vibrations, ranging for chest notes from 42 for the lowest bass, to 1,708 for the highest soprano. These notes are modified by the movements of the tongue, teeth, and lips for articulate speech.

The voice is not greatly exercised in school, because much time is given to study, writing, etc., but every child should be taught to speak slowly and deliberately, raising the voice so that the sound may carry, and opening the mouth so as to articulate properly.

The pupil should stand erect with the head raised and the shoulders thrown back so as to allow of the free expansion of the chest. It is much easier to speak clearly when standing than when sitting; and in the correct attitude than in any other position.

There should be no constriction round the waist in the shape of belts or corsets as the abdominal muscles should have full play when breathing. The teacher should notice whether there is undue action of the collar bones during singing or speaking as this is a sign of abdominal constriction. Singing is very useful as a chest exercise if properly conducted by a teacher who can show the pupil how to draw in the breath properly, so that the notes may be sustained for a longer or shorter period. Singing should be taught in a quiet class room, and there should be avoidance of sudden and unsuitable interruptions. It is not to be used as an accompaniment to muscular exercises. In muscular exercises the upper extremities, and to a certain extent the lower extremities, act with the trunk as a fixed point from which the movements are made. In singing, and to a lesser degree in speaking, the chest is in movement and the extremities at rest, that is, the extremities become practically the fixed points from which the muscles of the chest act.

Hoarseness is caused by mucus on the vocal chords, but the character of the voice is affected by the healthy, or unhealthy, condition of the mucus lining of the mouth, nose, and throat, as well as of the larynx.

Clergymen's sore throat is caused by an attempt being made to speak long and loudly, by persons whose usual articulation is slovenly and indistinct.

Children, from shyness, often speak in a mumbling way with closed teeth and half-opened lips and the teacher must overcome this timidity, before further progress can be made in teaching the child to speak properly.

Stammering is a disturbance of the formation of sounds

and is due to long continued spasmodic contraction of the diaphragm. Speech being dependent upon an expiratory blast, is hindered through the spasm preventing expiration. The treatment is to regulate the respirations. One way in which this is done is by making the person sing instead of speak. Stammering may be brought on by mental excitement or emotional disturbance.

In stuttering, the defective speech is due to inability to form the proper sounds.

Stammering and stuttering are more common in boys than girls and may be acquired by imitation in children predisposed by inheritance. In stammering there is usually visible muscular spasm in the face and other parts, and the teacher should try to lessen the duration and severity of each attack, by arresting the spasm when it commences, by telling the boy to stop speaking and try again presently.

Amongst other defects of speech are a thick and indistinct utterance in mouth breathers due to impediments to proper breathing through the nose, such as adenoid growths and enlarged tonsils.

Whispering is speech without voice, that is to say, it is produced by the action of the tongue, teeth, lips, and the resonant cavities, nose, mouth, and throat, but not by the action of the vocal cords.

A remarkable change takes place in the voice at puberty. The larynx increases in size, and, in boys, the Adam's apple is seen. The voice change is more troublesome in boys and much more marked than in girls.

It also occurs later—in girls at about thirteen, and boys at about sixteen years. At this time the voice

should not be over exercised. This more particularly applies to singing.

The shouting of boys and girls in games need not be interfered with as it is due to natural ebullition of spirits.

The Chest.—The chest contains the lungs, heart and great vessels. The lungs extend from about one inch above the collar bone to the lowest rib at the back, but in front to between the sixth and seventh ribs. The respirations in children range from 26 per minute at five years to about 20 per minute at the termination of school life, *i.e.*, between the ages of fifteen and twenty. In adults, from 16 to 18·7 per minute is the normal range. Expiration is slightly longer than inspiration, the ratio being about eight to six in the case of children and seven to six in the case of adults.

AVERAGE CHEST GIRTH.

AGE NEXT BIRTHDAY.	TOWN ARTISAN CLASS. (*Dr. Robert's.*)	ALL CLASSES. (*Report of Anthropometric Committee.*)
10 Years.	24·08 ins.	26·10 ins.
11 ,,	24·34 ,,	26·53 ,,
12 ,,	24·93 ,,	27·20 ,,
13 ,,	25·24 ,,	28·03 ,,
14 ,,	26·28 ,,	28·46 ,,
15 ,,	27·51 ,,	29·74 ,,
16 ,,	28·97 ,,	31·53 ,,
17 ,,	29·38 ,,	33·64 ,,
18 ,,	30·07 ,,	34·19 ,,

The girth of the chest during moderate expansion is about half the height of the body. The chest increases

in inspiration about five or six inches in the case of adults and proportionally less in children. The lowest limit of the lungs in inspiration is about one inch lower than the line maintained during rest, and in expiration it rises about one inch above that line. A comparison is shown in the table of chest girth in certain classes. It has been shown that in country public schools it is comparatively greater than in elementary and other schools where less attention is paid to physical development.

The chest is closed in below by a flat muscle called the *Diaphragm.* The central portion is tendinous and supports the heart, and is relatively fixed whilst the surrounding muscular fibres act in inspiration. The increase in the chest capacity is partly by the chest walls being raised, and partly by the lowering of the diaphragm or floor of the chest. In expiration, the diaphragm is passive and is pushed up by the abdominal muscles.

The lungs, with the heart and big blood vessels, occupy the cavity of the chest.

THE LUNGS are the organs affecting the aeration of the blood; together they weigh about forty-two ounces, the right lung being about two ounces the heavier. The air passes through the larynx or voice organ into the trachea, or wind pipe, a tube which is continued well down into the chest where it divides into the bronchi, which divide again and again, like the branches of a tree, into the bronchial tubes. These terminate in the air cells, where the air comes into contact with the small blood vessels, whose walls, being very thin, are

able to absorb the oxygen of the air and give up the carbon dioxide, which is the result of oxidation in the body.

The mass of the lungs is made up of the air cells, and is of a spongy nature. It completely surrounds the bronchi and bronchial tubes, which are lined with ciliated epithelium and are kept in an open condition by the cartilaginous rings in their walls. These cilia resemble very minute hairs and act so as to eject foreign bodies, such as dust particles, from the lungs.

The respiratory capacity of the lungs is about 230 cu. in., of which about 100 cu. in. of residual air always remains in the chest; 20 cu. in. is expired and inspired as tidal air, in ordinary respiration. 110 cu. in. of reserve, or supplemental air, may be expelled from the lungs by additional effort after a normal expiration. An additional 110 cu. in. can be inspired in forced respiration; this is called complemental air.

THE HEART is on the left side of the chest and the beats may be felt 2 in. below the nipple, and 1 in. towards the middle line of the body. The pulse beats are about ninety at five years of age decreasing to about seventy at twenty years.

The heart's action is easily accelerated in children by slight ailments, and is, of course, increased by exercise.

The child's chest should be broad, and he should stand with his shoulders square, level one with the other, and well set back.

The Spine.—The vertebral column or spine is at the back of the chest. When looked at from behind it should be perfectly straight and erect. There is, however, always a slight lateral curvature, with the convexity towards the right side, except in left-handed persons, when it is towards the left. This is caused by the extra amount of use by one side. The spine is made up of small bones called vertebræ. Seven of these are the neck bones (cervical vertebræ), then come twelve back bones (dorsal vertebræ), and five loin bones (lumbar vertebræ), the termination of the spine being in the sacrum and coccyx, or rudimentary tail.

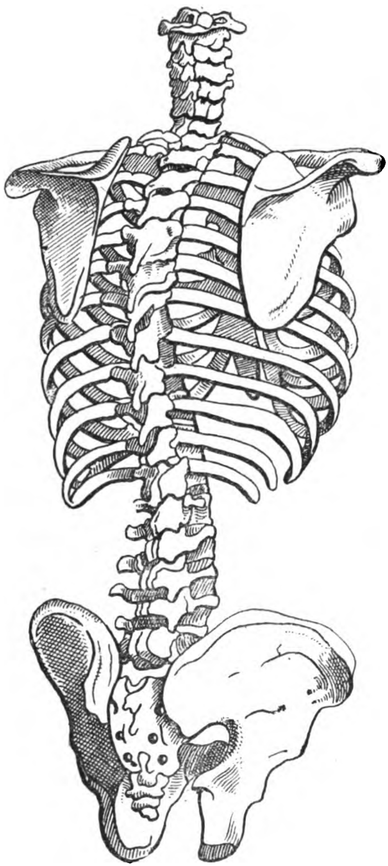

Fig. 8.—The Spine and Bones of the Trunk.

Looked at in profile the spine has several curves.

The neck or cervical curve is slightly convex in front; the dorsal curve is concave in front, changing to convex in the lumbar or loin region, and becoming concave again for the sacrum and coccyx (Fig. 8).

The separate bones of the spine called vertebræ are piled one above the other, large in the loins, and getting smaller towards the neck. These bones consist of flat masses of bone forming the bodies, and certain processes behind forming the ring for the spinal cord, and behind that the spines which act as a protection for the delicate spinal cord or marrow, and also for the attachment of the muscles which keep the body erect. Between the body of each vertebræ there is a flat disc of fibro-cartilage which acts as a buffer against shock. All the parts are intimately bound together by ligaments, and the whole is embedded in muscles. There is a very limited movement of the spine, both laterally and backwards and forwards.

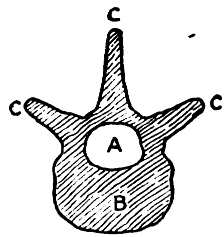

Fig. 9.—A Vertebra in Section. (A) *Spinal Canal for Marrow;* (B) *Body of Vertebra;* (C) *Processes for attachment of Muscles.*

The spine is kept erect, in part only, by its bony structure; the upright position being largely maintained by the action of the muscles of the back, etc., balancing the body correctly. The curves of the spine should not be excessive, and it must constantly be borne in mind that the constant use of unsuitable postures may have a marked and lasting effect upon the curvatures, and that chiefly in the weakly children who are the most likely to

assume the awkward pose, on account of earlier fatigue of certain sets of muscles.

Undue curvature in the lumbar region is found to exist in children with weakness of the spinal muscles, and arises from the fact that when the arms are thrown forward the centre of gravity is thrown forward. This can be counterbalanced by strong spinal muscles maintaining the erect position. If, however, the muscles are weak, the shoulders fall back as a counterbalance to the extended arms and the loin is unduly curved. This position was once a temporary fashion, known as the "Roman Fall," in distinction to the "Grecian Bend." It is often to be found in children with weakness of the nervous system, and is referred to as lordosis.

Lateral curvature of the spine may be suspected if the scholar is noticed to constantly lean to one side whilst at work. One shoulder seems higher than the other, and there may be twitching or uneven movements of the two sides. The postures may arise in a child with defective vision through the endeavour to find an easy position for effective sight of the object placed before it.

Lateral curvatures are most frequently caused by unsuitable postures, but they are usually divided into three classes: (1) Constitutional causes, (2) A mixture of constitutional and local causes, and (3) Local causes, chiefly mechanical, and due to the continued use of muscles on one side or the other, instead of alternately. There is often slight normal convexity to the right side which may be disregarded. In the first-class the deformity comes on in very early life. It may be hereditary or due to the improper surroundings of the

child as regards food, air, etc. The second and third classes form about ninety per cent. of the whole. In the second-class the local causes may combine with hereditary causes or with rickets. The commencement of the deformity may arise from an unsuitable posture in nursing, the child being held constantly on the one arm so that the infant has always the same arm round the nurse's neck. If the child is nursed on the left arm, the child's right shoulder is elevated to throw the right arm round the nurse's neck, and the left shoulder is lowered and the spine hollowed towards that side. The deviation of the bodies of the vertebræ is greater than that of the spines, so that the curvature is really greater than it appears externally. The third class of cause occurs before the completion of growth, and usually arises from unsuitable attitudes in the posture assumed for standing, sitting, etc.

Fig. 10.—Lateral Curvature of the Spine.

In standing, children rest principally on one leg, or cross-legged, but rarely in the best position with the feet slightly apart and the body supported evenly on both legs. This is the position of least fatigue. Standing at attention causes considerable muscular effort, whilst the force of supporting the weight on one leg whilst the other is thrust forward causes a convexity of the spine towards the side on which the weight is supported. In the position of the military stand easy, the weight is on the left leg, and the convexity to the left counteracts the frequently normal convexity to the right.

When examined in the nude condition the curvature may not be immediately discovered by the unpractised eye, but the dropping of one shoulder will readily be noticed and also the raising of the hip on the same side. The lower tip of the shoulder blade may then be noticed to project unduly. Such a position naturally tends to increase the deformity the longer it remains uncorrected.

The real cause of the deformity is found in debility of the system. The muscles become easily tired, and the child assumes the wrong position as a relief. Badly made desks and seats still further increase the bad tendency. Muscles not in proper condition require physical culture to improve the tone, and it is also necessary to give tone to the muscles at different changes of work, as when changing from rest to strain. Before a writing lesson, short dumb-bell exercise should be given so that the trunk muscles may be stimulated to resist the lopsided tendencies of the writing position.

Muscular exercise brings an increased supply of blood

to the parts and promotes growth of muscle and bone. Unused muscles degenerate.

Muscles, if not frequently exercised, lose the power of co-ordination, or working in harmony, hence the sedentary student becomes more ungainly without acquiring greater knowledge than the student who takes that proper amount of physical exercise which renders him graceful and not less learned. The time devoted to moderate physical exercise induces an increased physical well-being. The increased blood supply which results enables a greater amount of brain work to be done in a given time, owing to the increased energy of the brain, due to the more perfect oxidation of the brain cells.

CHAPTER IV.

THE ARMS AND HANDS.—Blueness of Hands in warm weather.—Imitation of movements.—Hand postures: the nervous hand; the energetic hand; the straight hand; the tired hand; the hand in rest; the feeble hand; the hand in fright; the convulsive hand. THE LEGS AND FEET.—Knock knees.—Bowed legs.—Arched instep.—Skipping.—Crippled children.—Special arrangements for teaching.—Rickets, commoner in towns and in boys: lack of milk diet. THE SKIN.—The epidermis; the chorium.—Fat beneath skin.—Maintenance of equable temperature.—Respiration through skin.—Sebaceous secretion: sweat.—Water does not pass through epidermis.—Removal of epidermis by blisters, injury, etc. THE TEETH.—Development of the teeth.—Cleaning teeth.—Particles of food as breeding grounds for germs.—Hard fibrous food as a cleanser. Loss of teeth disqualifying for Army, etc.—Teeth and their development.—Lessons immediately after meals. GROWTH.—Varies for different portions of body.—Brain develops early: rates of growth for boys and girls.—Weights at different ages.—Relation of physical to mental growth.—Precocious children.

The Arms and Hands.—The upper limbs should be in proportion, not over long, and with well developed muscles. The hands should be neither dry and hot, nor cold and clammy. Hands blue with cold, even in summer, are often found in nervous children. When told to hold out the hands, they should be stretched out in front firmly and decisively with the hands flat in the plane of the arm, and the thumbs held out by the side of the fingers. When told to imitate movements and the right arm is held out for an example, very young

children facing the teacher will hold out the left which is opposite. This shows a lack of mental quickness which may be one of a number of serious symptoms in children over seven years of age, if persisting after the error has been pointed out.

Dr. F. Warner gives eight types of hand postures which are of use in estimating any nervous deviation in children.

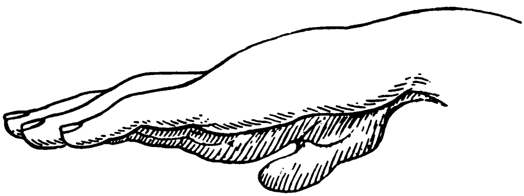

Fig. 11.—The Nervous Hand.

In the nervous hand the wrist is dropped and the fingers extended. (Fig. 11.)

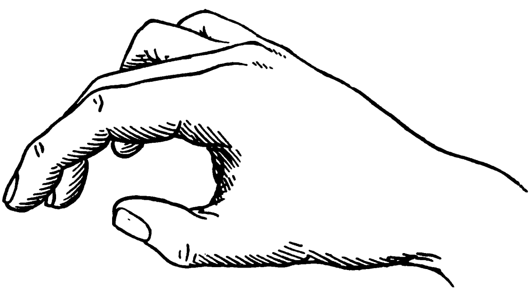

Fig. 12.—The Energetic Hand.

In the energetic hand the wrist is extended backwards, and the fingers and thumb are gently flexed. (Fig. 12.)

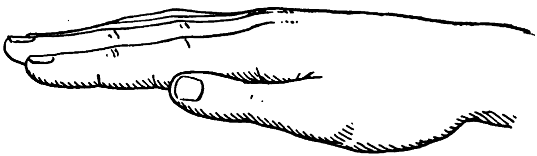

Fig. 13.—The Straight Hand.

The straight hand when extended is the normal type, flat, with the thumb level with the fingers. (Fig. 13.)

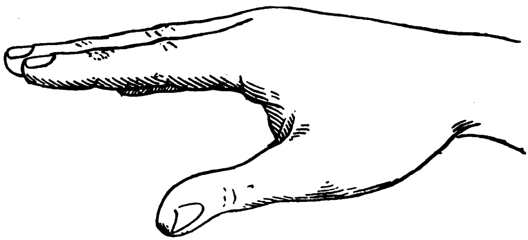

Fig. 14.—The Tired Hand.

The tired hand is the hand held out straight, but with the thumb dropped. It may be noticed if children at the end of an examination are asked to extend their hands. In several of them the thumbs will be dropped. (Fig. 14.)

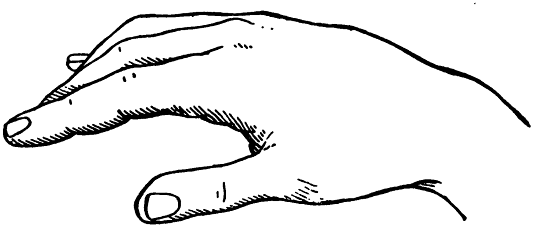

Fig. 15.—The Hand at Rest.

The hand at rest is slightly flexed at the wrist and fingers. (Fig. 15.)

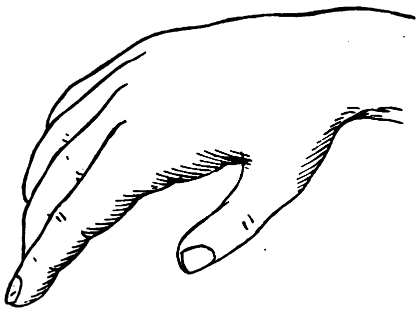

Fig. 16.—The Feeble Hand.

The feeble hand is an exaggeration of the last. (Fig. 16.)

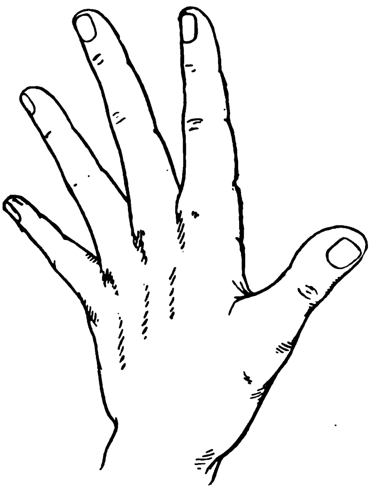

Fig. 17.—The Hand in Fright. *Fig. 18.—The Convulsive Hand.*

The hand in fright is extended at the wrist and also at the fingers. (Fig. 17.)

The convulsive hand is a closed fist, but the thumb is fixed on the palm of the hand while the fingers are closed over it. (Fig. 18.)

The Legs and Feet.—The lower limbs should be straight without weakness at the knees or ankles. The feet should be very slightly turned out, the position of a soldier, or a ballet girl, is exaggerated. Knock knees, or bowed legs are usually the result of rickets. The child should stand evenly on the legs, if the child constantly rests the weight of the body on one leg, hip joint disease may be suspected.

The feet should be arched. Skipping is an exercise that tends to strengthen the arch of the foot.

The toes should be separated and not compressed into narrow pointed shoes.

Crippled Children.—Special arrangements may be provided for crippled children whose physical defects render them incapable of receiving instruction with ordinary children.

Many cripples can be taught in the ordinary schools. Special attention must be given to children with club foot, those with limbs shrunken from infantile paralysis, bow legs, or knock knees, and similar partial disablements, as they are, many of them, incapable of performing sustained mental work. Special physical exercises should be arranged for them, as they will naturally be unable to join in regular drills with more robust children. Every case of this kind should be known to the managers, and special arrangements should be made, as such cases must be considered separately.

Rickets.—Children suffering from this condition are frequently seen in towns, more commonly in the infants' school, and amongst boys than girls. They are short for their age, and grow up stunted; the head is misshapen,

and the forehead bulgy, giving the head the appearance of increased size and brain power. Legs are either bowed, or knock-kneed, and the child's movements are consequently impaired. The ends of the bones near the joints are enlarged, or the child may be pigeon-breasted. Lack of proper milk diet from infancy onwards is the chief cause of rickets. Such children are usually dull, and delicate in health. Improved knowledge of the proper management of infants will do much to prevent this condition. Avoidance of bread and farinaceous foods to babies under nine months old, and the disuse of the cheaper kinds of patent foods are to be recommended.

The Skin.—The skin of the body is constantly growing, and constantly wasting and renewing itself. It is impermeable to water from without, but moisture readily passes from within outwards. In health the surface should be cool and moist, but not unduly so. It is elastic and flexible, easily folded and unfolded, and it is transparent—as may be seen from the appearance of the veins beneath it.

The skin consists of the epidermis and the chorium, or true skin.

THE EPIDERMIS consists of several layers, the outside of varying degrees of hardness according to the position on the body. In dark coloured races pigment cells are abundant in the deeper layer.

THE CHORIUM, or true skin, contains the hair and sebaceous follicles, the sweat glands, blood vessels, fat, etc. The fatty tissue beneath the skin fills up depressions and protects projecting parts. It is a bad

conductor of heat, and is therefore of great use in maintaining the equal temperature of the body. The elastic movable skin with its fatty padding beneath affords protection against injuries from without. The dry and hard epidermis, devoid of blood vessels, affords protection against the absorption of poisons. It exerts a pressure on the minute cutaneous blood vessels, so that when the epidermis is rubbed away the skin is always red and moist. There is respiration through the skin, carbonic dioxide and water being given off. Varnishing of the skin will cause death from asphyxia sooner than ligature of the lungs. A child gilded to represent Cupid in a procession died almost suddenly of asphyxia.

There is sebaceous secretion from the skin. This is a fatty material which keeps the skin supple and the hair from becoming dry. Sweat is alkaline, becoming acid by mixture with the sebaceous fatty excretion of the skin. The amount excreted is very large and is increased by high temperature. Watery solutions will not pass into the skin, but fatty substances may be rubbed in. When the epidermis is removed, as by a blister, absorption may readily take place. Gases may also be absorbed through the skin.

Teeth.—The nails and teeth are merely special developments of the skin. The teeth should be carefully attended to, and it is advisable to teach children to brush their teeth, or at least wash out their mouths at night. This will remove the particles of food left between the teeth which is the chief cause of the decay of teeth, the particles of food forming good breeding grounds for the growth of the decay germs.

Decayed teeth cause fœtid breath, and undue salivation. Secondary abscesses are set up, causing pain and loss of sleep, and the tenderness of the teeth and mouth make the child avoid the harder parts of farinaceous food, which are so necessary to the proper growth of the poorer children who are debarred from tender meat on account of its expense.

A certain amount of indigestible fibrous matter in food is most useful in keeping the teeth clean, and much of it is useful in bone formation, as in whole meal of wheat, etc. Thus unsuitable food, resting in the interstices of the teeth, may lead to decay, which entails underfeeding of the child; this induces physical weakness, with the ensuing mental weakness. Not only so, but the loss of teeth, removed for tooth-ache, is a very serious detriment in after life, as it may debar a man from entering the army, navy, etc., and, by causing deficient mastication, render the person liable to indigestion.

The teeth appear at the following periods:—

TEMPORARY, OR MILK TEETH.

Central incisors	7th month.
Lateral ,, ...	7th to 10th ,,
Anterior molars	12th ,, 14th ,,
Canine	14th ,, 20th ,,
Posterior molars	18th ,, 36th ,,

	INCISORS.	CANINES.	MOLARS.	
Upper jaw	4 ...	2 ...	4	20.
Lower ,, ...	4 ...	2 ...	4	

The permanent teeth form beneath the temporary or milk teeth, which at about six years of age begin to be shed. The bony partitions above the permanent teeth

are absorbed, and the fangs of the milk teeth disappear so that they are loosened and easily removed.

PERMANENT TEETH.

First molars	6th year.
Central incisors	7th ,,
Lateral incisors	8th ,,
Anterior bicuspids	9th ,,
Posterior bicuspids	10th ,,
Canines	11th to 12th ,,
Second Molars	12th ,, 13th ,,
Wisdom teeth	17th ,, 25th ,,

	INCISORS.	CANINES.	BICUSPIDS.	MOLARS.	WISDOM.	
Upper jaw	4	2	4	4	2	32.
Lower ,,	4	2	4	4	2	

There is no reason why a child should not do lessons immediately after a meal. Digestion requires a large supply of blood to the digestive organs, and therefore there is less blood relatively supplied to the brain, but there is no reason to suppose that the blood required by the brain in a lesson is more than that required in play. Moreover, the lesson may be a sitting one and of a recreative nature, so that blood need not be drawn away unduly from the digestive tract.

Growth.—The old saying that the body is renewed every seven years is a misleading one. The brain cells are not renewed, but added to, in the course of growth and education. The brain has reached $\frac{5}{6}$th of its natural size at three years of age, and at seventeen it has reached $\frac{19}{20}$ths, but the nerve cells will go on increasing till forty-five years of age.

The body stops growing at twenty-five, except for the addition of fat. The boy is, age for age, heavier than the girl, but up to ten years the boy grows faster than the girl.

Then the girl grows more rapidly up to about fourteen when the boy takes the lead and maintains it. Surroundings have considerable influence on growth. In country public schools the average height of boys of ten to twelve is two and half inches higher than that of boys in town elementary schools. This is partly due to country air, as is shown by the slighter superiority of the country elementary school over that of the town; but the real advantages are due to better food and more physical training. The public school boy exercises his muscles in all possible ways, cricket, football, swiming, gymnastics, and all kinds of athletic sports. Not only so, but this training is continued to a later period of life; the elementary scholar closes his school life at fourteen, whilst the public school boy goes on to seventeen years.

Increase of weight should correspond with growth. Children in a high class for their age should show a corresponding physical development, and no child below the average weight should be allowed to compete in his lessons with older children as there is extreme probability of breakdown from mental overstrain. We are all somewhat lower in stature on going to bed than in rising in the morning, and this is more marked in children. This difference depends upon higher general tone of the tissues after rest. Children are said to increase most in weight during the holidays, especially between July and November.

A person who at birth weighs from 6 to 12 lbs., will, when fully grown, weigh from 130 to 180 lbs. Measurements of children should be taken from time to time;

height, chest, girth, and weight. These measurements will not only interest the child, but will give the teacher the opportunity of making a more intimate acquaintance with the pupil, so that the effect of instruction and exercises will be more readily noted, and the advantages of experience brought to bear on any necessary modifications of routine.

THE AVERAGE HEIGHTS AND WEIGHTS OF SCHOOL CHILDREN.

	GREAT BRITAIN—TOWN AND COUNTRY. (*Report of the Anthropometric Committee, 1883.*)				• BOSTON, UNITED STATES OF AMERICA, (*Dr. Bowditch, 1877.*)			
AGE LAST BIRTH-DAY.	BOYS.		GIRLS.		BOYS.		GIRLS.	
	INS.	LBS.	INS.	LBS.	INS.	LBS.	INS.	LBS.
5 yrs.	41·03	39·9	40·55	39·2	41·74	41·20	41·47	39·82
6 ,,	44·00	41·4	42·88	41·7	44·10	45·14	43·66	43·81
7 ,,	45·97	49·7	44·45	47·5	46·21	49·47	45·94	48·02
8 ,,	47·05	54·9	46·6	52·1	48·6	54·43	48·07	52·93
9 ,,	49·7	60·4	48.73	55·5	50·09	59·97	49·61	57·52
10 ,,	51·84	67·5	51·05	62.0	52·21	66·62	51·78	64·09
11 ,,	53·5	72·0	53·10	68·1	54·01	72·39	53·79	70·26
12 ,,	54·99	76·7	55·56	76·4	55·78	79·82	57·16	81·35
13 ,,	56·91	82·6	57·77	87·2	58·17	88·26	58·75	91·18
14 ,,	59·33	92·0	59·80	96·7	61·08	99·28	60·32	100·32
15 ,,	62·24	102·7	60·93	106·3	62·96	110·84	61·39	108·42
16 ,,	64·31	119·0	61·75	113·1	65·58	123·67	61·72	112·97
17 ,,	66·24	130·9	62·52	115·5	66·29	128·72	61·99	115·84
18 ,,	66·96	137·4	62·41	121·1	66·76	132·71	62·01	115·80

N.B.—Height without shoes. Weight in ordinary clothing.

RELATIVE HEIGHT OF BOYS 11 TO 12 YEARS.

	AVERAGE HEIGHT.
Public schools (country)	54·98 ins.
Middle Class schools (towns)	53·85 ,,
Elementary schools (agricultural districts) ...	53·01 ,,
,, ,, (towns)	52·60 ,,
,, ,, (factory, country districts)	52·17 ,,
,, ,, (factory, towns)	51·56 ,,
,, ,, (industrial)...	50·02 ,,

In considering mental development with a view to testing the capabilities of school children, the physical condition of the child must be taken into consideration, together with the mental.

AVERAGE HEIGHT OF AMERICAN CHILDREN 5 TO 18 YEARS.		AVERAGE WEIGHT OF AMERICAN CHILDREN.		COMPARATIVE WEIGHT OF ENGLISH CHILDREN OF THE SAME HEIGHT.	
BOYS.	GIRLS.	BOYS.	GIRLS.	BOYS.	GIRLS.
55·2 ins.	54·1 ins.	82·3 lbs.	78·3 lbs.	81·7 lbs.	71·0 lbs.

From the tables it is clear that surroundings have a considerable effect upon the development, the American children showing not merely a greater average height than the English, but a comparatively greater weight.

The same difference may be seen by comparing the height of boys in different social spheres.

"The human body is an economical machine, which yields a very large return of energy in comparison with what is spent upon it in the way of fuel, that is to say, food. Physiologists calculate the work done by the body in foot tons, a foot ton of work being represented by the energy required to raise one ton weight one foot high. A hard-working man in his day's labour will develop power, I suppose, equal to about 3000 foot tons, this amount representing both the innate work of his frame involved in the acts of living, and in his external muscular

labour as a hewer of wood and a drawer of water. A man's heart, in twenty-four hours, shows a return equal to 120 foot tons; that is, supposing we could concentrate all the work of the organ in that period into one big lift, it would be capable of raising 120 tons' weight one foot high. Our breathing muscles, in twenty-four hours, develop energy equal to about 21 foot tons, and when we add in the actual work of the muscles, and that expended in heat production, we arrive at our 3000 foot tons, or thereby, as the daily expenditure of energy. All this power, moreover, is developed on about 8⅛ lbs. of food per day, the supply including solid food, water, and oxygen. No machine of man's invention approaches near to his own body, therefore, as an economical energy-producer; and this for the practical reason that the human engine gets at its work directly, and without loss of power entailed in other appliances that have to transmit energy through ways and means involving friction and other untoward conditions."
—WILSON.

CHAPTER V.

EFFECTS OF INSTRUCTION AND EXERCISES ON GROWTH.—Writing—Bad positions.—Oblique and Vertical Writing.—Position of the light. SEATS AND DESKS.—Too long maintenance of one position.—Length of writing lessons; break for muscular exercises.—Girls at needlework.—Children with loosely folded arms: disadvantages. PLAY AND GAMES.—Action on the muscles; absorption of oxygen; discharge of carbonic dioxide; increase of muscle; increase of sinew; automatic action; saving of nervous energy; difficulties of the beginner in working new muscles.—Heat produced in muscles by exercise.—Use of fat.—Effect of exercise on fat people; poisonous products not got rid of quickly; difficulties from bulk.—Fat men thinner; thin man puts on flesh.—Exercise as a controller of nutrition; digestion improved; constipation obviated.—Effect of exercise on personal appearance; on moral character; on mental work. PHYSICAL TRAINING.—Suitable time for games and exercises; out of doors.—Much oxygen needed during exertion.—Fresh air during exercise.—Walking: parts exercised.—Running: not for middle-aged.—Jumping and skipping: strengthening of joints.—Riding: certain deformities increased.—Dress.—Swimming: excellent general exercise.—Cycling: precautions to be taken.—Cricket and football.—Hockey.—Lawn-tennis.—Baseball and Rounders.—Suitable clothing.—Development of chest.—Inquiry into physical condition.

IT is most important to observe accurately the effect of instruction and physical exercise upon the pupil. During instruction it is of great importance that the child should be made to assume a correct attitude, as it has already been shown that if the general physique is below par, constant use of a particular pose may cause permanent deformities.

In writing, children are liable to lean too much to the

left,—sometimes, even resting the elbow on the desk and supporting the head with the hand. This position may be assumed merely through laziness, or the child may be tired, and in the result, one eye being nearer the paper than the other the writing is oblique. It is for this reason that vertical writing is advocated, the child being obliged to sit straight in order to make the up and down strokes upright. A twisted position cramps the chest, and throws the weight of the body on the hip.

It is inadvisable to give the same seat in the class-room always to the same scholar, as the light being always on the same spot slight spinal deviations may be set up by the constant assumption of the same pose. Light should properly come from the left side and slightly behind the pupil so that shadows should not fall where the writing is. It is very difficult to arrange this in the older school-rooms, as windows were put in less with a view to educational necessities than the saving of expense.

Seats and Desks.—Seats and desks are of great importance in maintaining a proper posture, but length of lessons must also be considered. Even the most suitable position if maintained too long at a time, tends to relaxation of the muscles, drooping at the shoulders, and imperfect expansion of the lungs, if not to any actual curvature of the spinal column.

If the desk be too high when the scholar begins to write, one shoulder is raised in order to rest the arm on the desk. On the other hand, if the desk be too low the scholar bends forward and the shoulders become rounded. The head may become congested by being

held too low, and imperfections of vision may be increased through the eyes being too close to the paper. The desk should be slightly sloped and not too far from the seat. The latter defect causes the same errors in posture, as when the desk is too low.

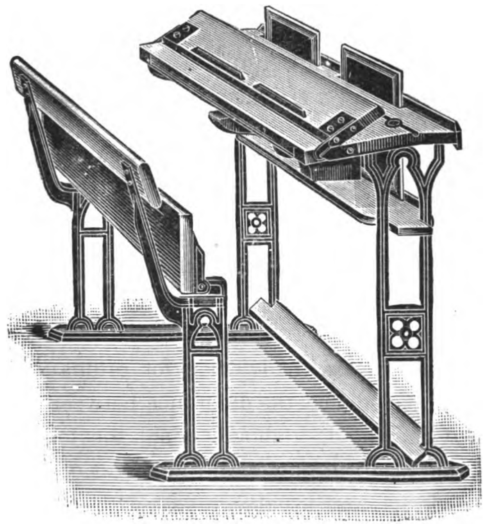

Fig. 19.—Desk with Adjustable Slope and Movable Seat.

Seats must be of a suitable height for each particular child. If the child is too tall for the seat his thighs are bent up towards the body and a cramped position is produced. If the child is too short for the seat his legs dangle and his feet do not rest on the ground or on the foot-rests. This causes pressure on the nerves and bloodvessels at the back of the thighs, and the sensation of "pins and needles" arises. This may also occur

when the seat is too narrow to support the length of thigh. A back-rest is also necessary, or immediately the spinal muscles become tired the scholar will lean forward on the desk and compress the chest, and thus interfere with respiration.

Writing should not continue in any class for more than half an hour without a break, and for infants and young children a few minutes at a time is sufficient. A short interval of exercise of the arms and shoulders will give sufficient stimulus to the muscles to prevent them readily relaxing to the forced positions and will enable the writing to be resumed without inconvenience.

For writing, the edge of the desk should slightly overhang the front edge of the seat; for other purposes the seat may be about the same distance further back. Movable desks or movable seats are made for the use of schools, as chairs are inadvisable for ordinary scholars. It is recommended that the difference between the height of the seat and the desk should equal the length of the forearm, that is, about one-sixth the height of the scholar. The best desks are usually made with an adjustable slope; 30 deg. is the angle best suited for writing, and 40 deg. or 45 deg. for reading.

The height of the seat should be such that the scholar when seated upright should have the thighs flat on the seat, and the feet planted firmly on the foot-rest, provided beneath the desk. If there is no foot-rest the feet must be placed flat on the floor so that there may be no stretching of the muscles.

The back-rest should be slightly inclined backward, and so made as to support the small of the back,

and extending as high as the bottom of the shoulder blades. Single desks are preferable to long desks, as with the latter children are apt to adopt awkward attitudes in order to prevent copying.

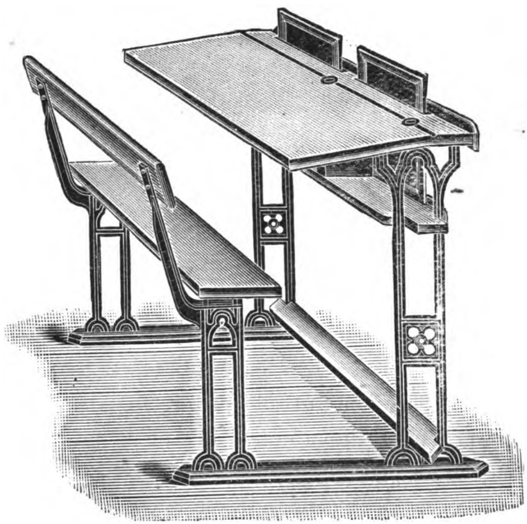

Fig. 20.—Desk with Fixed Slope and Seat.

Desks and seats of various sizes should be provided, so that all scholars may be properly suited. This is hardly practicable in elementary schools. Children who stand or sit for any length of time with their hands upon their heads are liable to assume a position with the head poked forward. Leaning over desks that are too low for them induces in children the same awkward position, and results in rounding of the back and contraction of the chest.

Girls at needlework frequently sit sideways with their legs crossed and the head bent over the work. In such a position the spine is bowed and the weight is thrown on one hip. Children should not sit with their arms folded loosely in front of them as the arms drop and the weight is thrown on the abdomen, whilst the shoulders and head are thrown forward. The action of the diaphragm is thus restricted and respiration is impeded. The weight falling on the abdomen may also interfere with digestion.

Play and Games.—In exercise, the blood vessels of muscles are dilated, and the chemical re-action from being alkaline when at rest becomes acid. Carbon di-oxide is driven out and carried off by the veins, and oxygen is absorbed from the arteries, the blood supply being increased. The amount of water in the muscle is increased, whilst the amount in the blood is decreased and heat is formed.

By exercise the muscular tissue is increased—" Muscle makes muscle "—but the various tissues, other than the muscular tissue, and the fat amongst the meshes are diminished. The tendons or sinews become strengthened; but there is a limit to the growth of every muscle, after which it begins to waste. Muscles in good condition contract readily, and acquire the habit of acting in concert without the direct influence of the will. In this way the nervous system is saved the expenditure of energy, and the athlete in training makes many of his actions automatically. This may be readily understood by the novice in learning new movements. A beginner

with the bicycle rapidly tires because he is using muscles in maintaining his equilibrum, etc., that have hitherto been almost unused. This is not merely because his muscles are weak from want of use, but because they do not act in co-ordination, and so save the expenditure of nervous force by the brain and spinal cord. As soon as practice causes these muscles to act almost automatically, this expenditure is saved, and the feeling of weariness is no longer felt. A memory has been developed in the muscular centres of the brain and spinal cord and the element of fatigue is removed.

Not only are individual muscles improved by exercise, but the trained man learns to breathe with economy; he ceases to breathe with needless vigour. The nervous system is also improved in tone. Restless movements, twitchings, etc., cease, and the man improves in deportment, gait, and expression. The art of the athlete is to carry out all his movements with the least expenditure of energy. A novice will expend as much force in cycling one mile as will carry the trained cyclist twenty. The heat devoloped in the muscles causes them to contract more readily, hence the expression "warming to his work."

Heat thus produced by action causes certain chemical changes, mostly oxidations. Carbon di-oxide, urea, uric acid are formed, and as these are poisons they must be got rid of by the lungs, skin, etc.

By exercise fat is got rid of. Fat in the body exists largely as a reserve fuel for combustion. When a fat man begins to exercise he rapidly becomes exhausted, because his fat or reserve fuel is being burnt up too

quickly, and he is unable to get rid of the poisonous products of combustion (*urea*, etc.) fast enough. He is also hampered by weakened muscles, and by the mechanical obstacle of his great size.

As the muscles are trained, they become harder, and it is more difficult to cause a bruise. In judicious training the fat man gets thinner, but the thin man gains flesh and weight.

Exercise may be regarded as a controller of nutrition, it enables the thin man to assimilate or take up from his food for the increase of useful tissue, and the fat man to dissimilate or reject from his food undesirable matters so that useless tissues cease to be formed.

In exercise, the action of the heart is increased from ten to thirty beats, the skin becomes red from the increased circulation of blood, and perspiration is given off. Digestion is stimulated and appetite increased, and more particularly when the abdominal muscles are exercised, the bowels become more regular in their action and constipation is decreased. A large amount of carbon is given off in exercise, therefore a corresponding amount of carbon must be consumed in the food.

TABLE OF THE AMOUNT OF CARBON GIVEN OFF IN REST AND EXERCISE.

	ABSORPTION OF OXYGEN IN GRAMMES.	ELIMINATION IN GRAMMES.	
		CARBON DIOXIDE.	WATER.
Rest	708·9	911·5	828·0
Exercise ...	954·5	1284·2	2042·1

Nitrogen is given off in greater amount after exercise rather than during exercise. Those in exercise, therefore, require more meat or other nitrogenous food.

Exercise has considerable effect upon personal comeliness. The thorax becomes well developed, and the man or woman breathes with ease. The shoulders are squared and thrown back. The spine appears as a valley amongst the muscles of the back and not as a mountain range of spinous processes beneath the skin. The skin is firm and clear, and there is an absence of flabbiness. The walk is springy and the postures are graceful. The development of the body by training, also has good mental and moral effects. Boys who work hard and play hard do not ape the vices of men, they are not loafers, but simple wholesome-minded straightforward lads.

Taking part in games teaches the young to be quick of hand and eye, and prompt in judgment, and to learn the advantages of discipline and self-control. Patience, fairness, and unselfishness are necessary in the proper playing of all games.

Games are necessary as a relaxation from the discipline and restraint of the class-room. The child longs for movement. The moment the class is over the scholars rush with a shout for the playground, pleasing excitement takes the place of mental concentration, respiration is quickened, circulation is increased, and the spirits become buoyant and lively. The most suitable games for the young are those providing free play of the muscles and unrestrained use of the voice, with little need of mental exertion, and, of course, without using

voice and general movement simultaneously. Games to have their proper effect upon physical and mental development need supervision. Care must be taken that the backward retiring children are allowed to get their full share of the exercise, as they are the very ones who are most in need of it. Not only so, but even those who are lively and vigorous are apt to devote themselves to the exercises for which they are by nature most adapted, and in which they most easily attain proficiency. Though this is good in a general way, it is inadvisable that in games development should be specialised instead of being generalised, as even special attainments are not best carried to success, except in company with general development.

Physical Training.—In elementary schools in towns it is not possible to develop games to the extent that is effected in public schools in the country. It is therefore advisable to arrange systematised exercises as a part of the school curriculum. These physical exercises should be taken during breaks in the school hours, and not during play time. The morning is best for the more arduous exercises, and those with the hardest work should be taken early when the scholar is fresh. These exercises should be taken—when possible—out of doors, but choice should be made of a part of the playground sheltered from wind in cold weather, and from the sun in hot weather. During exercise the sunshine should not be allowed to fall for too long on the scholar's back, nor directly in his eyes.

In cold weather exercises entailing rapid movements

of the lower limbs are best suited to send a pleasant glow through the body. The playground should be well drained so that water should run off quickly and leave the ground dry. Children when perspiring freely should not be allowed to stand in cold winds, as muscular rheumatism, or worse ills may follow. When it is necessary that the exercise should take place indoors every possible opening for the supply of fresh air should be made use of on account of the extra amount of oxygen required to make up for the loss by oxidation in the contracting muscles.

The system of exercise for school children should be free from complicated or difficult movements. The exercise should be easy to learn, and should be performed with little or no alteration. Musical accompaniment is useful, especially for the younger children.

It is necessary that the ordinary dress should be suitable for the performance of the exercise, and the whole exercise should be accomplished whilst the child is standing on the feet. No part of the body or the hands should touch the ground during exercise. The teachers must be capable of performing the exercises themselves, as children can learn by imitation quicker than by explanation.

WALKING.—This is the easiest form of exercise for all ages. It exercises chiefly the leg muscles, but also the muscles of the loins, back and abdomen, and respiration and circulation are increased. The spine should be kept straight, the head erect, and the shoulders well back. The position of the body is easier than in marching. The walker should not roll like a country lout walking

from the hips, nor like the fashionable lady on her toes and high heels, nor with a slouch like an untrained school boy.

Boots and shoes should be properly made with low broad heels, and the inner side of the shoe straight so that the great toe may be free and not pressed up against the other toes as in the common pointed shoe. The heel part of the shoe should fit neatly, and the toes should have room for movement.

Walking with an object is to be recommended. Shooting and golf are excellent reasons for walking.

Skating.—This is a modified form of walking.

Running.—Running is essentially an exercise for the young, in the aged it is dangerous, but in very young children it seems to be less tiring than walking.

Jumping and Skipping.—Jumping encourages well co-ordinated muscular contractions which must be vigorous and instantaneous. Skipping employs nearly all the muscles of the body. It strengthens ankles and knees and the arches of the feet. It increases the respiratory movements and should be practised in the open air.

Riding.—Riding is an exercise for the rich, but an admirable one. The muscles of the thigh and back are mostly brought into use. A good seat depends more on the art of balancing the body than of gripping the saddle.

It is not good for girls with commencing lateral curvature of the spine, and overgrown girls are apt to become round shouldered. Close-fitting habits and long skirts are a great hindrance to women in riding.

Swimming.—Swimming increases the respiratory movements and straightens the back. The movements of the limbs are free, but the arms tire before the legs, and the sense of exhaustion is most felt about the shoulder. Arrangements should be made for swimming in connection with every school, and it could be taught in a very small bath. A bath 3ft. 6in. deep, and just wide enough to give the arms free play, and about 18ft. long would serve for teaching children, who could perfect themselves elsewhere.

Girls should be taught as well as boys, as it is an exercise which gives a graceful figure and carriage. The water should be warmed to about 70 deg. F., and bathing should not be allowed till about two hours after a full meal, nor when the person is exhausted or chilled. If arriving at the swimming place hot, the bather should plunge in directly, and not cool down first. Children who have suffered from ear discharges should put a piece of cotton wool into the ears before diving. It is better to take several baths during the day than to remain too long, at one time, in the water. It is also dangerous to stand about, except during very hot weather.

Fencing, Boxing, and Rowing.—These are all of them very useful exercises, but more suitable to the older young persons than to school children. Rowing should not be attempted when wearing tight corsets, belts, etc., or rupture may result.

Cycling—This pastime should not be indulged in by children under nine or ten years of age. Care must be taken that the machine is not too heavy for them; some

light ladies' machines are better suited than those made specially for children. The gearing should be low, as the rapid pedalling is much better for the growing child than the slower exercise of greater force with a high gear. Care must be taken that the saddle is properly adjusted, neither too high nor too low, and not causing any undue pressure. Children learn quickly and soon acquire great facility. They should be encouraged in trick cycling and short runs at a moderate pace, but long journeys and tours should be forbidden.

Cricket may be played by girls as well as boys.

Football is one of the best of games for boys. "The very function and final cause of rough sports is to work off the superfluous animal energy for which there is little vent in the piping times of peace. Health, endurance, courage, judgment, and above all, a sense of fair play are gained upon the football field." (*Sherman*). Standing about to look at football matches in wintry weather is often fraught with danger.

Hockey.—This game has lately been much played by girls and young women. It is an admirable exercise when taken under general supervision. The limbs should be protected by thick stockings, gloves, etc., as serious bruises are sometimes caused by the clubs or ball. The jacket should be removed during play, and put on immediately active exercise ceases. My daughter's schoolmistress, who has had much experience, tells me that since the introduction of hockey she has noticed that the complaints of headache, etc.. are much fewer than formerly.

Lawn Tennis.—This game can be played on any

lawn or flat place, and by the two sexes together. Care should be taken to prevent children over-exerting themselves, and it is advisable that an interval should be insisted on between each set.

Baseball and Rounders.—These games can be played both in boys' and girls' schools. Baseball may be a very violent exercise if played with the full rigour of the game: face guards, pads, etc., being required to protect the more delicate parts. The game can be easily modified for use by girls and young children, when it makes a very suitable exercise. Rounders is practically a modification of the other game.

In all these games suitable clothing should be insisted upon. Not long ago, I saw ladies playing hockey in November in thin transparent blouses and light shoes. Woollen is the wear for all active sports, and extra wraps should be at hand for use during the intervals, more especially in winter. Boots or shoes should fit easily, and stout soles are indispensable for all winter games.

Physical Training of children should be begun early, and exercises should be made interesting by being conducted in classes. Such exercises should not take the place of outdoor games. Upper limbs may be encouraged by such amusements as battledore and shuttlecock, and the lower by such games as hop-scotch. Exercises which develop the chest must not only exercise the muscles, but increase the volume of the respiratory movements, and should be such as involve rapid limb movements in the open air. Large tonsils stand in the way of chest development. Young children must avoid exercises of strength or great speed.

Before arranging the child's exercises, inquiry should be made into his physical condition, and a record should be taken of each child. (1.) Name; (2.) Age; (3.) Height; (4.) Weight; (5.) General appearances; (6.) Chest girth; (7.) Breathing capacity; (8.) Span of arms; (9.) Girth of arms; (10.) Girth of legs; (11.) Presence of deformities or defects; spinal curvature, hernia, rickets, infantile paralysis, enlarged tonsils, etc.

CHAPTER VI.

FATIGUE.—Breathlessness.—Short and long runs.—CO_2 given off by a man.—Engorgement of the lungs.—Physical effects of exercise: exhilaration: discomfort; pain in heart, etc.; loss of colour; prolonged inspiration; fainting. —Training: second wind.—Relative fatigue: certain parts affected; galvanic current.—Complete local fatigue.— Fatigue arising from poisonous accumulations; from damage to structure of muscles.—Muscular stiffness.— Over fatigue; listlessness; inability to take food; prostration; fever predisposing to other diseases; absolute rest essential.—Muscular exertion measured as foot-tons.— Tuberculosis and spinal curvature.—Continued bad health as the result of excessive fatigue.—Exposure to cold after fatigue. TRAINING.—Regularity of life; smoking and alcohol; indigestible food; sleep; ventilation. INFLUENCE OF HEALTH ON EFFICIENCY OF WORK.—Paget's experiment; underfed children; mental fatigue. NEGLECTED AND DIRTY CHILDREN.—Example of cleaner children.— Pediculi.—Verminous Persons' Act.—Eczema.—Itch.— Ophthalmia: contagious; exclusion from school.— DEPRESSED HEALTH IN CHILDREN.—Pallor; overfeeding; unsuitable foods; constipation.—W.c. accommodation in boarding schools.—Re-absorption of poisonous matter from retained discharges; effect upon learning capacity.— Scrofula.—Wasting; worms; overwork.

Fatigue.—Breathlessness is usually considered one of the signs of fatigue. Breathlessness is produced when the power of the lungs to throw off the carbon di-oxide produced by the contraction of the muscles in exercise is less than the power of the muscles to contract. When the contraction of the muscles is greater than the lung power, breathlessness rapidly ensues—as in running for

short distances. In long distance running the muscles tire through general poisoning by carbonic acid, and breathlessness follows.

If the muscles put into action are very powerful, or if the action is very rapid, the production of carbonic di-oxide is so rapid that breathlessness comes on quickly as in short races, performing gymnastics, etc. There is no fatigue of the muscles. On the other hand, after prolonged exercise, as in long distance running or paper chases over a stiff country, there may be sudden collapse through accumulation in the blood of the poison excreted by exercise. Breathlessness in such cases is not marked. In a given time there is given off by a man :—

In sleep	... ...	0·35 gramme CO_2.
In sitting	... ...	0·60 „ „
In running	... ...	1·65 „ „

The engorgement of the lungs with blood also helps to cause breathlessness, as prolonged inspiration is needed to cause the blood to circulate freely through the air-cells, but inspiration is cut short in exercise by the prolonged expiration needed to throw off from the lungs the poisonous products resulting from exercise of the muscles.

When exercise begins, the lungs readily throw off the organic products, but as the exercise continues, more blood comes to the lungs and gradually the engorgement of the blood vessels tends to make inspiration fight against expiration and thus cause breathlessness.

Hence the first physical signs of exercise are a general sensation of warmth, flushing, an animated appearance,

sparkling eyes and cheerfulness due to throwing off of poisonous matters from the lungs in expiration.

This period of exhilaration may last from a few minutes to an hour or more, then come feelings of discomfort, pain over the heart, or in the head. The chest feels as if tightened by a band, there is clouding of the eyesight, sparks before the eyes, singing in the ears, etc.; the nostrils are dilated, the mouth and eyes widely opened. The flushing of the face is succeeded by a pale, wan tint, with a blackish violet colour of the cheeks and lips.

The violet colour is due to the retention of blood in the minute blood vessels of the skin, and the blood being charged with carbonic di-oxide is blackish like venous blood. The pallor of the skin is due to the emptying of small arteries, as the heart losing energy through the poisoning of the blood cannot send the blood into them. The pallor may be followed by a leaden hue. The period of inspiration becomes three times as long as expiration instead of being somewhat shorter. The symptoms become more urgent till the person faints.

Trained athletes soon learn to manage their breathing to the best advantage. As it is termed, they get their "second wind." A man out of condition is unable to do this.

Muscles may become fatigued without there being general fatigue. If the arm is held out at right angles to the body for a short time, the particular muscles become fatigued and the arm is dropped. This fatigue is only relative, as if a suitable electric current is applied

the muscles contract and the arm can be raised again. This may be repeated again and again until the muscles of the arm refuse to contract by any current or stimulus because the fatigue has become absolute.

Muscles will only do a certain amount of work. Muscles doing complicated work tire more quickly as the nervous energy is exhausted in directing the movements.

The poisonous organic matters resulting from the working of the muscles may in some way add to the fatigue. The muscle from being alkaline becomes acid. Lactic and uric acids are present, and substances like urea are formed; these are of a poisonous organic character.

The fatigue may also be due to actual damage to the structure of the muscle by compression or rupture of the fibres.

Muscular stiffness depends rather upon the condition of the individual than upon the amount of work done. Muscles may be fatigued without becoming stiff. Over-fatigue may leave a person merely listless, or there may be heaviness in the head, inability to take food, restlessness, sleeplessness, and utter prostration. In some cases there is fever (T. 104 deg. F.) that lingers about for a time till the patient falls a victim to some comparatively mild disease. Absolute rest and careful treatment is needed in these extreme cases.

The amount of work done by different kinds of muscular exertion is sometimes reckoned in foot-tons of energy, but this reckoning is not of much value in considering fatigue, as no calculation is made for relative matters,

such as the time occupied in the work, etc. Rowing one mile at racing speed = 18·56 foot-tons. Walking one mile at ordinary pace = 17·67 foot-tons. (For units of energy see Page 113).

The rowing race occupies	6 minutes
The walk "	20 "

Violent and extreme exercise may lead to injurious results. Boys are often knocked up for days after a paper chase, when the course has been too long, or the speed too great. Children inclined to tuberculosis may develop disease of the spinal column through excessive gymnastics. Lateral curvature of the spine has already been referred to. Sometimes excessive exercise may be followed by general weakness of health, which in middle-aged people may be permanent. In following up the history of certain university athletes, it was found that only about six per cent suffered permanently from the effects of over exercise.

The results of indiscretion by exposure to cold or wet during athletic exercises must be reckoned separately. Rheumatism, inflammation of the lungs, etc., may arise in this way. Such attacks occur when the exposure is prolonged, or when the person is overtired at the time the exposure takes place.

Training.—Training is conducted under much more rational conditions than formerly. Extreme regularity of life is of the highest importance. Exercise must be progressive and well timed. Meals must be taken to the minute. The person should take a substantial breakfast, a light lunch, a still lighter tea, and a substantial, but

not heavy dinner, when the day's work is done. He should rest after each meal. Alcohol and smoking are prohibited. Indigestible foods should be avoided; pork, veal, shell-fish, pastry, starchy foods and sugar should be taken sparingly. Butter, fruit, and plain dishes may be taken with impunity. Meat may be taken three times a day. Drink should be taken after meals rather than with them. Drink should not be limited, but only taken when there is thirst. Sleep is of great importance. "Early to bed and early to rise" is a good maxim, and the bedroom should be freely ventilated.

INFLUENCE OF HEALTH ON EFFICIENCY OF WORK.—Mr. Paget, M.P., divided a village school into two equal divisions. In one division the scholars were kept constantly at book work, in the other for half the time the scholars were employed gardening, with the result that the division spending all the time at book work was beaten in the examination by those who had only given half the time in preparing the subjects for examination. The gardening kept the pupils in better bodily health, with the result that they learnt better. It has been also shown that underfed children are unable to work as well as those obtaining sufficient food.

In mental fatigue there is either increased motion of the limbs, fidgetiness, or decreased movement amounting to prostration. There is often fulness under the eyes, and increased movements of the eye. The horizonta lines on the forehead are deepened owing to action of the frontal muscles, while the young student shows excessive sensibility to reproof, irritableness and temper, followed by headache, loss of appetite and disturbed sleep.

Neglected Children.—The Board of Education state that "it is the duty of the parents not only to send their children to school, but to send them in such a state of cleanliness as to prevent their being a nuisance to other children." The Board did not think the refusal to admit a boy in such a dirty state could be held to be unreasonable. Every effort must be made by the school authorities to improve the state of such children before resorting to exclusion.

A general condition of dirt is the commonest cause of complaint. The children are rarely washed, and their clothing appears to be the remains of tawdry finery begrimed in the dust and dirt of slums. It may be necessary to visit the parents, and call attention to this want of cleanliness, but an impression may be made upon the children by pointing out the contrast that exists between them and the tidier scholars. In such children lice (*pediculi*) find a fertile breeding ground. In the head louse (*pediculus capitis*), the eggs are deposited on the shafts of the hair, and are small oval, semi-transparent bodies, attached by a pedicle, or stem, to the hair. The young are hatched in about five days. The louse is semi-transparent, of a dirty white colour. It has six legs, with claws for seizing the hair, and prominent eyes. It is furnished with a sucker, which is capable of piercing the skin and drawing blood. The *pediculus vestimenti*, or clothes louse, is somewhat larger. The eggs are deposited not on the hair of the skin, but on the fibre of the clothing.

Lice may be cleared away by bathing with alcohol. This has a solvent effect on the sticky material by

which the eggs are attached to the hair. Various preparations of mercury are also used, but they must be applied before irritation of the scalp has been caused. For clothes-lice the garments must either be destroyed or baked in a disinfecting oven. Under the Verminous Persons' Act, 1897, local authorities can make arrangements for cleansing such persons in a public establishment arranged for the purpose, and pressure should be put on authorities to make this provision. By the irritation of pediculi, eczema is set up on the scalp, and this is frequently accompanied by swelling of the superficial glands of the neck. Eczema on the body from this cause is rarely met with in the young, though common amongst old people. Some children are naturally more liable to be infested with these pests than others; and care should be taken to exclude affected children before the parasite can be transferred to the cleanly, from whom it often causes considerable trouble in removal.

Scabies or Itch is caused by a minute insect called the *Acarus Scabiei.* It is found in the soft skin of the flexor surfaces of joints, but most commonly between the fingers. The insect burrows under the skin and lays its eggs there. The burrow is like an old pin scratch, and has a dotted and beaded appearance with ragged dirty edges at the opening. By inserting the point of a needle along the burrow the insect can usually be withdrawn for examination, as it adheres to the point. The irritation of the insect causes itching, and scratching is resorted to, which sets up a kind of eczema of the skin. Weak sulphur ointment smeared over the body, except

the face and scalp, just before going to bed will usually effect a cure in three or four days. Close fitting garments should be used to sleep in.

OPHTHALMIA.—This disease begins with heat, redness, swelling and pain. Then there is some discharge which rapidly increases in quantity and soon becomes thick and purulent. The disease is highly contagious, and is very liable to spread through schools. It is advisable as a matter of precaution to exclude children showing any signs of redness and watering of the eyes. It may be only a slight cold, or it may be the beginning of measles, whooping cough or German measles. Children dwelling in slums, who are underfed and not cleanly kept, are very liable to this disease.

SIGNS OF DEPRESSED HEALTH IN CHILDREN.—*Pallor* is due to the impoverishment of the blood. The red blood corpuscles are reduced in number. It is a sign of imperfect discharge of the vital functions.

In children, the commonest causes are connected with interference with the digestive processes. It may be temporarily caused by overfeeding with unsuitable foods, such as cakes, pastry, unripe fruits, etc., and is quickly removed by the administration of a dose of castor oil. If not properly attended to, diarrhœa may be set up and the pallor becomes accentuated. Some children will have a rapid rise of temperature after a surfeit of unsuitable food.

Constipation is another common cause of pallor. Children need to be taught to empty the bowels at regular times. This is very difficult in day schools as in the hurry of starting in the morning the most

convenient hour is not made use of. In this case many children will make a convenience at some later time of day, and it will be well that such arrangement should not be interfered with. In boarding schools it is most important that ample w.c. accommodation should be provided, and a teacher should be told off to see that the scholars make the daily visit. The increased learning capacity of the pupils will well repay the extra trouble, for it must be remembered that all matters intended to be discharged from the body if retained are liable to undergo partial re-absorption, thus causing a poisoning of the blood which predisposes to other ills. This cause of pallor is very common in big girls about the age of puberty, and should be promptly attended to.

Scrofula affecting the glands is usually accompanied by pallor. Scrofula is not now considered to be the same disease as consumption, though allied to it, and many children whose glands enlarge and become so diseased as to require removal, grow up strong and healthy.

Pallor may also be caused by constricted and tight fitting clothing, such as belts and corsets. Pallor due to want of air and exercise is referred to elsewhere. (Page 133).

Wasting.—Loss of flesh follows pallor if the exciting cause be not removed. It is an accompaniment of all exhausting diseases. It also may arise from local affections such as the presence of worms in the intestines, abscesses arising from injuries, and occasionally from over-work.

CHAPTER VII.

FOOD FOR CHILDREN.—Nitrogenous.—Animal tissue chiefly nitrogenous.—Constant oxidation; urea; uric acid.—Proteids of blood; reserve; wasting.—Non-nitrogenous.—Fats; heat energy.—Starches; food sparers partly take the place of proteids and fats.—Diet of the poor.—Minimum daily need of foodstuffs.—Fluids: after meals.—Salt; vegetable feeders.—Increase of food with exercise.—Diet of children.—Proportion of nitrogenous to non-nitrogenous food.—Effect of sleep on digestion.—Too great frequency of meals.—Excess of food: indigestion; increase of body weight; fat; gout, etc.; excess of water.—Underfeeding; starvation; muscular twitchings; inattention to work. CLOTHING.—Protection; normal temperature; radiation and conduction.—Woollen; variable climate; absorption of moisture; non-conducting properties of air; effect of washing on wool.—Cotton: not very absorbent; conduction of heat.—Flannelette; inflammability.—Linen: more absorbent than cotton.—Silk: good absorbent and non-conductive qualities.—Tight clothing.—Bare limbs.—Feet.—Damp clothes. NERVOUS CHILDREN.—Infancy; early symptoms; exciting causes.—Education.—Over-pressure.—Explosiveness of nervous tissue.—Results.

Food for Children.—Foods are divided into nitrogenous and non-nitrogenous, mineral salts and water, and food accessories such as tea, coffee, alcohol, etc. The non-nitrogenous foods are sub-divided into fats, carbo-hydrates, and vegetable acids.

NITROGENOUS FOODS.—With the exception of the bones, the greater part of the body of an animal is nitrogenous matter; the liquids largely containing nitrogenous sub-

stances in solution. Oxidation of the nitrogenous matter (proteids or albuminoids) in the body is constantly going on, about 500 grains of urea and 10 grains of uric acid being excreted daily by the kidneys; these two compounds largely consist of nitrogen.

The nitrogenous foods absorbed from the digestive tract are transformed into the proteids of blood. When the body is deprived of nitrogenous food, it draws upon the proteids of the blood, and partly on the tissues themselves. When the reserve is exhausted, the tissues begin to waste. On the absorption of proteids depends the working activity of the body. Muscles, nerve cells, glands, etc., are dependent upon proteids for their action. The chief nitrogenous foods are parts of muscle, of the blood, eggs, and portions of the seeds of cereals and leguminosæ.

FATS.—Fat is used by most nations, but in greater amount in cold climates than in hot. Fat is a source of energy and heat in the body, and accumulates in the body as a reserve force, easily dissimilated and very combustible. In hard work more fat is wanted. Fat in the body is not derived from the fat eaten, or only to a limited extent, as it has been shown to be derived in part from the proteids, and in part from the starchy foods.

CARBO-HYDRATES OR STARCHES.—These foods act as proteid and fat sparers. Carbo-hydrates cannot altogether take the place of proteids, but they may take the place of fats. The poor consume more starches than fats from motives of economy, but how far one may replace the other has not been shown. Either taken in excess will cause digestive troubles.

TABLE OF THE MINIMUM DAILY NEED OF FOODSTUFFS (*König*).

CONDITION.	WEIGHT IN GRAMMES.		
	PROTEIDS.	FAT.	CARBO-HYDRATES.
Child up to 1½ years	20-36	30 45	60-90
„ 6 to 15 „	70-80	37-50	250-400
Man	118	56	500
Woman	92	44	400
Old man	100	68	350
Old woman	80	50	260

It will be seen that the proportion of fat and starch is greatest in young children.

WATER is essential to life. Fluids should not, however, be taken with food, but after meals.

SALT (*sodium chloride*) is more necessary to vegetable feeders, because vegetables contain salts which excite an increased secretion of sodium chloride in the urine of man, whereas a certain amount of salt is present in flesh. It is also a source of the hydrochloric acid in the gastric juice. The absence of salt in the food leads to digestive troubles, the salt in the body being absorbed and not being replaced

PHOSPHATES are very important in the food, especially of young and growing animals. Phosphates are not absorbed readily unless sufficient salt is contained in the food. Phosphates are present in fish, coarse parts of meal, etc. Phosphates of calcium and magnesium are of

great importance in the formation of bone, and the absence of them is one cause of rickets.

CARBONATES, SULPHATES, AND IRON are also necessary to a proper diet, the last being an important constituent of the blood. The total salts amount to about 30 grammes daily.

The amount of food taken must increase with the exercise; this, of course, applies principally to proteids and fat. The proportion of nitrogenous to non-nitrogenous food should be about one to five, and of fat to carbo-hydrates about the same (one to five). Among the working classes there is always deficiency of proteids and fats, and excess of carbo-hydrates owing to the large proportion of bread in the food.

DIET FOR CHILDREN FROM SIX TO SEVENTEEN YEARS OF AGE (*König*).

	oz.
Meat (raw)	6
Bread	10½
Potatoes	6¼
Fat (butter or lard)	½
Milk	8¾
Flour	3½
Vegetables	6½
Water	20-30

Sleep diminishes digestion; hence food should not be taken just before going to bed. Food taken too often tends to diminish the activity of the digestive juices and gives no rest to the alimentary tract.

EXCESS OF FOOD.—Excess primarily produces indigestion. The body weight may gain chiefly by deposition of fat. Excess of proteids causes disorders of the liver and muscles, gout, rheumatism, etc. A diet of proteids,

with deficiency of fat and carbo-hydrates causes **leanness,** the fat of the body being absorbed on account of the fat-producing foods being reduced in quantity. Excess of fats and starches tends to corpulence and dyspepsia. Great excess of water leads to oxidation of the proteids of the body.

UNDERFEEDING.—A vigorous adult dies when he loses two-fifths of his body weight; children succumb sooner. The child has thirst, as it requires extra water for the oxidation of the proteids of its own body, this oxidation being the result of their deprivation from its food. Faintings may take place, more especially when food is withheld. Pulse beats and respiration are slower. There is muscular weakness, the fat is used up and the child grows tall and thin. Muscular twitchings or St. Vitus's dance may be noticed, and mental weakness may degenerate into imbecility. When the underfeeding is merely comparative, the child grows thin, is restless, and unable to pay proper attention to work.

Clothing.—Clothing is primarily a protection for the body against heat and cold; more especially against cold, so that the body may be maintained at 98·4 deg. Fah., the normal temperature of the body.

Clothing must be so arranged as to prevent the radiation or conduction of heat without interfering with the evaporation of perspiration. (See Chapter IX.)

WOOLLEN MATERIALS are usually considered the most suitable for general wear in such a variable climate as England. Nothing chills the body more readily than wind, and when there is wind and cold combined the

thickest clothing should be worn. Several layers of clothing are warmer than one thick garment, as air is retained between the layers and acts as a non-conductor. It is partly for the same reason that wool is worn. The rounded fibres of which it is composed are coarse and woven loosely together, so that air is retained in the meshes. It is of itself also a non-conductor of heat, and a great absorber of water, which is taken up in the meshes and then evaporated by the heat of the body. Woollen garments after frequent washing harden, and the soft fibre shrinks and becomes non-absorbent. Woollen garments worn in summer should be thin and lightly woven. Woollen materials do not burn readily.

COTTON.—The fibre of cotton is hard, does not absorb water and does not shrink when washed, but it is a better conductor of heat than wool. It absorbs odours readily, and has recently been prepared in a form of weaving known as cellular, which allowing of layers of air between the meshes makes it a non-conducting form of clothing. It is cheaper than wool. Cotton is made up with a mixture of wool under the name of flannelette, though the wool is often infinitesimal in amount. This form of material is very combustible.

LINEN.—Linen is a good conductor of heat and feels cold to the touch. It absorbs water better than cotton.

SILK.—This material approaches wool in its absorptivity and non-conducting capacities, but is expensive as an article of clothing.

Wool is best worn next the skin, and should form the chief part of the child's dress. In summer, cotton frocks may be worn over light woollen underclothing.

Woollen stockings or socks should be worn all the year round, thread and silk being reserved for very special occasions. Constrictions of tight clothes should be avoided, as air cannot get in between the layers to serve as a non-conductor of heat. Belts, garters, etc., should be replaced by suspenders. Tight gloves and boots may cause chilblains by impeding the free circulation of the blood. Bare chests should be avoided. Bare legs and arms in well fed children do not seem to cause much harm. Bare feet are not often seen in England, but it is probable that they would be attended with less danger than is the wearing of defective shoes and boots.

Children should never sit in damp clothing or damp shoes and stockings, as after exercise the bodies of children cool rapidly and chill may result.

Nervous Children.—Every teacher should understand that certain children, often very intelligent, come under this category, and must be very carefully treated if the nervousness is to be kept in check or cured, as ill advised methods will easily turn the nervous child into the idiot or the lunatic.

Nervous children may be classed in indistinguishable steps from the timid to the hysterical. Nervousness in children may begin in early infancy. The baby does not sleep quietly, it starts in its sleep, it has convulsions, and suffers from feverishness (sudden rises of temperature) without adequate cause.

Nervous children are easily excited. The visit of the examiner, too hard study, even tossing up and down,

and games sometimes cause intense excitement, followed by sleeplessness at nights, talking in sleep, starting up in terror and walking in the sleep. The child grows pale, stutters, assumes a strange expression, talks to itself, and has attacks of diarrhœa frequently brought on by some special excitement, such as having to repeat a lesson, or being called up before the examiner. These children are often of spare habit.

Amongst predisposing causes are threadworm and other parasites, rheumatism, and, of course, inheritance from parents—nervous, drunken, etc. For such children corporal punishment should be absolutely forbidden as it inevitably aggravates the disorder.

School hours and lessons should be short, with properly arranged exercises in the open air which should be neither slovenly and perfunctory, nor so much in the nature of competition as to be exciting. When there is any doubt, it is always best to be on the safe side, and suppose that the child is really suffering, than to punish for naughtiness what is in reality a serious defect in the constitution of mind and body.

Over Pressure.—It must always be remembered that in true education the child's brain is enlarged and not stuffed. It is this stuffing, or cramming, which leads to over pressure, and this cramming is largely the effect of competition which in true education should be avoided. The object of the teacher should be to develop the particular characteristics of each child's brain, not to assimilate every child to the pattern of some particular examination. Pressure in school for nine months, and

holidays for recuperation during three is wrong in principle. The education should go on continuously in such a way that the old idea of school should disappear, and the child's school days become the happiest in life. Life in school should be broken up into instruction, exercise, and games, and the more scientific the management of exercise and games, the more receptive the child will become to the instruction. Regularity should be the golden rule for diet, and the ordering of life. Parties, theatre-going, lectures, etc., should be the exception, not the rule.

School life begins too early. It is only the exceptional child who is fit to learn before the age of six, and the junior classes should be more in the nature of a crèche than a schoolroom. The bringing of very young children together creates many opportunities for the spread of disease, but it also takes children very much away from their homes, which are too often dirty and anything but suitable for rearing men and women either mentally or physically healthy.

Sir J. Crichton Browne says:—"The brain is made up of explosive material, the explosiveness of which may be heightened or reduced. In states of disease such as insanity or epilepsy the brain substance, or certain tracts of it, are raised to a higher degree of explosiveness, as gunpowder is when mixed with nitro-glycerine. In states of idiocy or imbecility it is reduced to a lower degree of explosiveness, as gunpowder is when mixed with moistened clay, so that it only burns slowly away or will not light at all."

The explosions of nervous tissue are not visible,

their effects being observed after the explosion. Luckily in most cases the explosions usually take place in precocious children, and the symptoms have been already referred to, excitability, sleeplessness, etc. It is to such children that the teacher must devote most observation; amongst them may be a child who judiciously treated may grow into a genius, whilst among the remainder may be many bright children who can easily be coached for examinations and scholarships. Such children may be stable in character, and as long as they are in good health come to no harm by hard work; or they may be merely excitable children who are easily excited over their work, to the breakdown of their bodily health, and, if care is not taken in time, of their mental capacity.

CHAPTER VIII.

INFECTIOUS DISEASES.—Measles.—Premonitory symptoms; cold in head; spots in mouth; rash on body.—German Measles different from Measles.—Common cold; difference of symptoms.—Whooping Cough; character of cough; sickness.—Diphtheria; suspicious sore throat; glands of neck; examination for the bacillus.—Antitoxin; early application; decrease of mortality.—Scarlet Fever; sore throat; sickness; rash; appearance of the tongue.—Mild character.—Epidemic waves.—Effect of sanitation.—Peeling.—Discharges.—Continuance of infection.—Kidney Disease.—Premonitory rashes.—Smallpox.—Difference from Chicken Pox; pain in back.—Vaccination; a preventive; confers immunity against Smallpox. — Re-Vaccination. — Meningitis; sometimes infectious; tuberculous.—Ringworm; fungus; in scalp; on body.—Contagious Impetigo; originating in pediculi; easily inoculated.—Chorea; girls; onset gradual; movements; loss of weight.—Ophthalmia; photophobia; redness of conjunctiva; watering; discharges.—Acute conjunctivitis.—Chronic conjunctivitis; follicular conjunctivitis; trachoma.—Epilepsy; fits; suddenness; drowsiness; treatment.

Infectious Diseases.—Certain infectious diseases have premonitory symptoms by which they can be recognized or diagnosed at an early stage before they become intensely infectious.

MEASLES.—Measles may begin with high fever, aching pains and vomiting. This subsides a little and there

follows cough and sneezing, and watery running from the eyes with fear of light. The conjunctiva is reddened and the child looks very depressed, and as if it had a very bad cold. About the third day spots appear on the forehead and sides of the face. The spots begin as red points which are raised and feel shotty on the pressure of a finger. They form crescent-shaped groups on the body which soon become irregular. The child feels worse when the rash appears. Often before the rash appears on the face, if the child is made to open the mouth deep red spots may be seen about the back of the mouth and throat When the child appears to be suffering from a severe cold the throat should be looked at, and if these spots are seen the child should be sent home and the parent warned. Small white spots may also be sometimes seen on the inside of the lips and cheeks four or even five days before the general rash of measles appears. There is nearly always a very peculiar odour about children with measles.

German Measles.—This disease is very like a mild attack of measles. The symptoms are similar, but not so severe. The rash usually appears at the same time as the water running from the eyes, but in many cases the first symptom complained of is a stiff neck due to enlargement of the glands of the neck, such as is seen when pediculi are present in the hair. This disease is very infectious, though not as dangerous in its results as measles, and the patient usually feels better when the rash comes out. The spots are smaller and pinker than in measles.

Common Cold.—The symptoms are very similar, but

there is neither the depressed appearance noticed in measles nor the fear of light (photophobia).

Whooping Cough.—This disease in its early stage is very difficult to distinguish from a common cold. There is frequently vomiting, puffiness round the eyes, and the sputum is very thick and difficult to cough up, but the fact that it is *coughed* up by very young children should arouse suspicion, as in ordinary cough it is usually swallowed. Whooping cough and measles or whooping cough and German measles may attack the child at the same time.

Diphtheria.—This disease frequently attacks children suffering from measles. Crowing noise in the throat may be a sign of deep seated diphtheria, and is a serious symptom. Sore throat is always very suspicious. The fever is not necessarily severe. If the tonsils are seen to be enlarged and reddened with irregular whitish grey patches on them it is probably diphtheria. If the patches are on one side only, or if they extend to the uvula or parts around the tonsils, it is a more certain sign of diphtheria. The glands behind the angle of the jaw are felt to be enlarged beneath the skin. It is advisable that all children with sore throat should be seen by a doctor before being allowed to attend school. This may be difficult in elementary schools, but if the teacher is at all suspicious, the Medical Officer to the School Board, or the Medical Officer of Health, can be called upon to decide. Many cases of diphtheria are very mild, and a decision can only be arrived at by examining the throat for the presence of the bacillus Klebs-Loeffler (the bacillus of diphtheria). To effect this

the medical man has a glass tube into which a cork fits tightly, and into this cork a piece of wire is inserted, round the end of which a little sterilised cotton wool is wound. The tube merely protects this swab. To examine for the bacillus the doctor takes the swab out of the sterilised glass tube and passes it lightly over the diseased surface of the tonsil, and then replaces it in the tube, pushing the cork in tightly and sending it to the laboratory to be examined. This examination for the bacillus should be made before applications have been used, and although the presence of the bacillus confirms the diagnosis its absence does not show that the disease is not diphtheria. It is only a negative sign.

The infection lasts for about three weeks, but no child ought to be allowed to return to school till it has been proved that no diphtheria bacilli are to be found in the throat or nose, nor so long as discharges continue from the throat and ears.

Great importance should be laid upon early attention to all cases of sore throat, as by the early use of anti-toxin danger of death from this disease is almost abolished. The germ of the disease grows upon the tonsils, and there generates a poison which being absorbed in the blood causes degenerative changes in nerve tissue, etc. Anti-toxin is a preparation from the serum of the blood of the horse, an animal that is immune against (*i.e., cannot contract*) diphtheria. Horses being inoculated with diphtheria, their serum becomes more strongly immune against the disease, and when injected into the human body it acts as an antidote to

the poison generated by the germ. The earlier the antidote is administered in the case of infection, the greater is the chance of recovery. Anti-toxin is harmless to healthy persons.

SCARLET FEVER OR SCARLATINA.—Sore throat is present from the beginning. The whole of the back of the mouth and throat has a vivid velvety red appearance. One of the earliest symptoms is vomiting, and before many hours the rash appears on the neck and chest. The rash is bright red with little points in it which are not seen in any other diseases where the skin has a red flush. By passing the finger over the skin the rash disappears for a moment to immediately re-appear. In the early stages of the disease the tongue is covered with a creamy white fur in the centre and bright at the edges. It soon cleans and assumes a bright red strawberry-like appearance.

At the present time this is a very mild disease, only one or two cases in every hundred proving fatal, but formerly there was very great mortality. Whether this is due to epidemic waves, or not, is uncertain. These epidemic waves occur in many diseases. For many years the disease lies low, so to speak, and then from causes unknown it assumes a character of intenseness.

It is generally believed that the present mild form of the disease is due to the better sanitary surroundings in which people live at the present day.

About three weeks from the outset of the disease, peeling, or desquamation, of the skin takes place, and this continues till about the sixth week. Owing to the

mildness of some of the attacks it often happens that the first symptom noticed is the peeling of the skin. This takes place from all parts of the body, and children may frequently be seen picking the flakes of skin from their fingers. The toes and soles are the last parts from which skin comes off as a rule, and in any doubt about infection the boots and stockings should be removed.

Infection continues for about six weeks, but no child should be admitted to school till desquamation has ceased. Care should also be given to discharges from the nose and ears, or even from diseased glands, as infection often remains whilst these discharges continue. Children recovering are liable to such complaints as kidney diseases, etc. It will be observed that the premonitory signs of these diseases are somewhat similar, and it will always be advisable, when there is any suspicion at all, that the child should be sent home and not received at school again till it has been seen by a doctor.

In addition to the rashes described, there is in many cases what is called a prodromal, or forerunning, rash, usually very slight and fugitive, which should be brought to the notice of the doctor when possible.

Smallpox.—Epidemics of this disease occur from time to time. In a person who has been vaccinated the disease is usually very slight, just a few isolated spots feeling hard, like shot beneath the skin, when pressed. It will nearly always be found out that two days before the spots appeared there had been severe pain in the small of the back. Sometimes the first signs of rash

may appear in a form resembling measles, scarlet fever, or erysipelas, on the sides, abdomen, or inner part of the thighs. The true spots are usually seen on the forehead, face, and wrists. The patient feels better in mild cases after the spots come out. In severe smallpox the patient is so ill that a doctor is always called in.

CHICKEN POX.—In chicken pox the spots come out in crops after very slight malaise. The first crop is usually on the back or chest, but not always so. The day following a second crop appears, and the next day perhaps a third crop. By the sixth day the spots have all dried up and the child is well.

The following rules should be adhered to, unless specially modified by the Medical Officer of Health :—

INFECTIOUS AND CONTAGIOUS DISEASES: ISOLATION AND QUARANTINE.

N.B.—The table which follows has been compiled and reprinted with the kind permission of the Medical Officers of Schools Association, from the third and fourth editions of their "Code of Rules for the Prevention of Infectious and Contagious Diseases in Schools." Of this Code, all the more important recommendations, with regard to infectious diseases, have been adopted by the Minister of Public Instruction in France.

ISOLATION means the continued separation of the infectious patient from the healthy until after he has ceased to be infectious.

QUARANTINE means the similar separation of a *possibly* infected person until after the termination of the period at which he would (if infected) have developed characteristic signs of the disease in question.

The following Table indicates the periods of Isolation and of Quarantine which are generally applicable in the case of the principal Infectious Diseases :—

DISEASE.	ISOLATION OF THE PATIENT.	QUARANTINE, AFTER EXPOSURE TO INFECTION.
CHICKEN-POX.	Until every scab has fallen off (the scalp should be specially examined).	For 20 clear days.
DIPHTHERIA.	In no case for less than *four weeks*, provided convalescence is completed, and that there is no longer any sore throat, or any abnormal discharge from the throat, nose, ears, or eyes, and no albuminuria; and that bacterioscopic examination of the pharyngeal (or nasal) mucus for the specific bacillus has been attended with negative results; this examination having been made in not less than three days after the discontinuance of local antiseptic applications.	For 12 clear days.
GERMAN MEASLES (Rubella) and Epidemic Roseola.	For not less than *ten days* from the date of the appearance of the rash.	For 20 clear days.
MEASLES (Morbilli).	For not less than *two weeks* from the date of the appearance of the rash, convalescence being satisfactorily established.	For 16 clear days.
MUMPS.	For not less than *three weeks* from the commencement, provided that one clear week has elapsed since the subsidence of all swelling.	For 24 clear days.
OPHTHALMIA.	*See* "Ophthalmia," page 109.	
RINGWORM	*See* "Ringworm," page 108.	
SCARLET FEVER.	For not less than *six weeks* from the date of the appearance of the rash, provided that convalescence is completed, and desquamation has ceased, and there is no sore-throat, discharge from the ear, suppurating glands or eczematous patches.	For 10 clear days.
SMALL-POX.	Until every scab has fallen off, and the skin lesions have all healed.	For 16 clear days.
WHOOPING-COUGH.	For not less than *five weeks* from the commencement of the whooping, provided that the characteristic spasmodic cough and the whooping have ceased for at least two weeks.	For 21 clear days.

N.B.—Complete Disinfection of the person and of the clothing must be carried out at the termination of the period of Isolation or of Quarantine.

Vaccination.—This is the only preventive of smallpox. Communication with all parts of the world is so easy and so extensive that smallpox can at any time be introduced into England. The disease has an average incubation period of twelve to fourteen days; that is to say, twelve to fourteen days elapse from the date of infection to the appearance of the spots, so that it is possible for a person to be infected with smallpox in America, Russia, West Africa, or even Bombay, and not develop the disease till reaching England.

The liability to contract any infectious disease depends upon the absence of immunity in the individual. Some persons are immune from all infectious diseases, they never catch anything; whilst others take every disease to which they are exposed.

Vaccination, or Cow-pox, is a modified form of smallpox, having assumed a mild type from passing through the body of a calf. Vaccination confers immunity on individuals for varying periods of time. Four good marks on the arm will, in some instances, procure immunity for life, in others to puberty, and in others to school age. It is, therefore, necessary to re-vaccinate at the age of about puberty, or conclusion of school life. In Prussia, where this was made compulsory in 1874, there is practically no smallpox at all, as the whole nation has been rendered immune. It is necessary that at least four good marks should be made, as one mark can only procure immunity for a very short time.

Whenever cases of smallpox occur in the district, it is advisable to have recourse to a third, or even fourth, re-vaccination. In the recent outbreak in London no

one died of smallpox who had been re-vaccinated within ten years.

The risk, in vaccination, of inoculating other diseases has been grossly exaggerated. This never occurs if the lymph is good and the operation is carefully performed. At the worst far greater risks are daily taken by everybody in railway travelling, in eating oysters, etc.

MENINGITIS.—This is a disease of the membranes of the brain. There are several varieties; in its simple form it may arise from exposure to the sun, or shock—physical or mental—and it also follows on other diseases. It may begin with headache followed by delirium and stupor, or there may be vomiting and convulsions to begin with; but in some cases the attack is sudden and painful to witness. The disease may also arise from injury with fracture of the skull.

The commonest form is of tubercular origin, and in these cases the onset is not so rapid. Children are irritable and constantly crying, putting their hands to the head and complaining of pain. There is usually constipation. As the disease advances the child may be quiet and drowsy. There may be squint, and if the nail is drawn across the skin a red mark persists for some time.

Particular observation should therefore be directed to children showing any of these symptoms, and if they persist beyond a day or two, medical advice should be sought. Another form of meningitis occasionally occurs in epidemic form.

RINGWORM.—This contagious disease is common to man, dog, cat, horse, etc., but is usually spread from person to person by brushes, caps, and so on. It seems

to be commoner in delicate children, perhaps because the skin is of finer texture. It is caused by a fungus. In the scalp a round patch varying in size from a three-penny bit to a crown may be found on which are lustreless, opaque, brittle, swollen, and distorted stumps looking as if the hair had been nibbled off. Crusts may form, or the disease may be complicated with eczema. The disease may attack the smooth skin. The patches are often irregularly circular with well marked margins. It also affects the beard and nails. This disease is very contagious and children must be excluded from school whilst suffering from it. It is exceedingly difficult to cure even with much care and attention.

In cases of ringworm of the head, the scalp should be subjected to a careful microscopic examination in a good light, and the broken off hairs carefully scrutinised for signs of the ringworm fungus.

> "It is sometimes considered that ringworm is cured when the hair commences to grow on the affected areas, but this is not necessarily true, for it frequently happens that diseased broken-off hairs remain; and the malady may thus persist for months or years. It is often very difficult to detect the short diseased stumps, which protrude only an eighth of an inch or less, and it is important not to mistake closely-cut *healthy* hairs for diseased stumps."

Contagious Impetigo.—This disease usually occurs in badly nourished children. It usually begins from the irritation of pediculi (lice) in the hair. The irritation induces scratching of the head, the contagion is transferred to the face, and from the face the disease may be conveyed to other children not affected with pediculi.

Chorea, or St. Vitus's Dance.—This disease is more

frequent amongst girls than boys. It may occur in bright, well-made children, and is characterised by awkward twitches and movements, whilst the child may show weakness of health and childishness of manner. The onset is gradual in most cases, the fingers twitch and the girl drops things in a clumsy way. The shoulders may be moved up and down, and the feet shuffled about. The facial muscles are never still, the eyes are constantly on the move, and the mouth makes many grimaces. These movements may sometimes be averted by engaging the child's attention, but they soon recur. These children lose weight rapidly and often complain of "growing pains." The latter are due to muscular rheumatism, but the joints are also sometimes found to be swollen. In cases following on rheumatism or rheumatic fever there may be heart disease.

OPHTHALMIA.—This disease is sometimes epidemic in schools, more particularly resident orphan schools in connection with the Poor Law. The symptoms comprise fear of light, redness of the conjunctiva, watering, and later on purulent discharge and very serious evils. The first cases should be immediately isolated, and the towels, sponges, etc., used by the patients removed and disinfected. Each child should have separate articles.

"Every case of *acute conjunctivitis* should be isolated, pending precise diagnosis. The latter can, in many instances, be made with certainty only by a bacterioscopic examination of the discharge from the conjunctiva.

"In *chronic conjunctivitis*, a distinction should be made between two conditions that somewhat resemble one another, namely, Follicular Conjunctivitis and Trachoma (granular lids). The former is common among children of the poorer

class, and is not a serious ailment. The latter is an infectious disease, always calling for prolonged isolation and special treatment. If neglected, it is apt to affect the cornea, and thus damage sight."

EPILEPSY.—A child may occasionally be seen at school in an epileptic fit. The seizure is sudden, pallor of the face is followed by loss of consciousness and the patient falls. The hands are clenched and the limbs stiffened, the face is distorted, blue and congested. The tongue may be bitten by the closure of the teeth which set rigidly, and the foaming upon the mouth may then be tinged with blood. The child is very drowsy after such an attack and should be allowed to rest. Sometimes the attacks are very mild without convulsion. This is called "petit mal" by the French. These children should be trained under proper conditions in country places.

CHAPTER IX.

WARMING AND VENTILATION (THEORETICAL).—Heat requires a continuous supply of air.—Air for ventilation warmed.—Combustion of fuel.—Carbon and Hydrogen forming, with air, carbon-dioxide and water.—Removal of products of combustion.—Heat by friction.—Energy.—Foot-pounds.—Thermal units.—Heat of fuels.—Amount of heat for a penny.—Latent heat.—Specific heat. DISTRIBUTION OF HEAT.—Conduction.—Good conductors: metals.—Non-conductors: still air; asbestos.—Radiation.—Transparent media.—Polished surfaces.—Reflection.—Sun-burn from snow fields.—Convection.—Movement of air: warm air rises; cold air sinks.—Hot climates; lessened convection; punkahs.—Scents.—Convection in liquids.—Good building and fuel economy.—Damp walls and fuel consumption.—Moisture from gas.—Indirect ventilation.—Proper inlets. AIR.—Composition.—Impurity.—Weight.—Low barometer.—Density decreased by rise of temperature.—Carbon dioxide.—Standard of organic impurity.—Impurity.—Microbes.—Dust: when deposited.

WARMING and ventilation are best considered together. The continuous production of heat requires, as a rule, a continuous supply of air, so that heat is an important agent in ventilation. Air supplied for ventilation frequently has to be warmed in order to avoid the sensation of cold draughts. Heat for such purposes as warming must nearly always be due to combustion, that is to the chemical action caused by the combination of the oxygen of the air with such substances as wood, coal, oil, or coal gas. These substances are known as fuels

and may be solid, liquid, or gaseous, and consist chiefly of the solid element—carbon, and the gaseous element, hydrogen, in combination. On combustion the carbon unites with a portion of the oxygen of the air to form carbonic acid gas (carbon di-oxide), whilst the hydrogen unites with another portion of the oxygen of the air to form water. This breaking up and the re-combination of carbon, hydrogen, and oxygen causes the evolution of heat.

One pound of carbon in burning forms 3·7 lbs. of carbonic acid gas (CO_2) and gives out enough heat to raise 87 lbs. of water from 62 deg. F. to the boiling point, 212 deg. F. One pound of hydrogen (190 cu. ft.) produces 9 lbs. of water, and the heat evolved will raise 417 lbs. of water from 62 deg. F. to the boiling point.

In the evolution of heat it is therefore necessary to bring to the fuel a constant stream of air for the supply of oxygen and arrangements must also be made for removing the carbonic acid and other products of combustion. Heat may also be produced by friction. If a flat mass is dragged along a horizontal table by a string to which a weight (say of 100 lbs.) is attached, then for every foot the 100 lb. weight falls a certain quantity of heat is generated by the friction produced between the table and the mass upon it.

The amount of heat thus produced is small compared with the heat caused by combustion. 1 lb. of coal would have to fall 2,000 miles to produce the same amount of heat as would be evolved by its combustion. The falling weight is said to lose energy by falling, and energy may be measured in this way. The energy of bodies may take

other forms. A weight may be raised, a moving mass may be stopped, or a compressed spring may resume its natural shape. Thus the energy to raise 10 lb. through a vertical height of 50 ft. is expressed as 500 foot-pounds; 20 lbs. raised 25 ft. would show an equal amount of energy expended.

Heat may be expressed in the same way, *i.e.*, as foot-pounds; but it is found more convenient to refer to the amount of heat necessary to raise 1 lb of water from 32 deg. to 33 deg. F. The amount of heat to raise 1 lb. of water through any degree between 32 deg. and 212 deg. F. (the boiling point) is practically the same, and this is called the British Thermal unit. The number of lb.-F. units of heat produced by 1 lb. of different kinds of fuel is as follows:—

Coal	14,000 lbs.-F.
Coke	12,600 ,,
Peat	9,000 ,,
Wood	7,200 ,,
Petroleum	21,000 ,,

The number of lb.-F. units obtained for a penny are:—

Coal	95,000 lbs.-F.	Approximately.
Coke	150,000 ,,	
Peat	45,000 ,,	
Wood	54,000 ,,	
Petroleum	21,500 ,,	

The heat of combustion is as follows:—

1 lb. of Carbon is	13,000 F. units.
1 lb. of Hydrogen is	62,500 ,,

With these figures the amount of heat evolved by fuels can be estimated.

Latent heat must also be taken into account. Each pound of ice in melting absorbs 143 lbs.-F. units of heat

without raising the temperature of the ice, and the boiling away of 1 lb. of water into steam is caused by the transference of 966 lbs.-F. units of heat, but the steam is of the same temperature as boiling water. The heat in these cases is rendered latent, and the amount used up in the fusion or evaporation of the substance is referred to as latent heat.

In the same way, when water evaporates, heat becomes latent, thus causing a cooling of the surrounding substances and the water itself.

A cold substance in moist air causes a condensation of moisture and a liberation of latent heat.

Specific Heat.—This varies for different substances, and means the number of units of heat required to raise the temperature of 1 lb. of a substance through 1 deg. F.

Note the specific heat of the following substances:—

Water	1
Air (when the volume is constant)	·169
Air (when allowed to expand)	·238
Iron	·114
Ice	·504

Water absorbs more heat than most substances. By cooling 1 lb. of steam at 212 deg. F. to 60 deg. F., the latent heat being added, 1,118 lb.-F. units of heat would be transferred, whereas only 36 lb.-F. units would be got out of 1 lb. of air similarly treated.

Distribution of Heat.—If substances at different temperatures are placed together, the temperature of the different substances will gradually become uniform.

This may be effected in different ways.

1. *Conduction.*—In conduction the hot layers pass the heat to the cooler layers in contact with them in what is

called a slope of temperature. This slope is steeper whilst the differences in temperature are greater, and lessens as the temperatures become equalised. But conduction has little effect in heating air, except through convection.

Most metals are good conductors, particularly copper, but air would be a good non-conductor if kept still. Thus flannel, cotton wool, swansdown, etc., are warm, because air is retained in the meshes. This prevents the escape of heat from hot bodies. Asbestos, glass, wood, wool, indiarubber, fossil meal (kieselguhr), paper, etc., are non-conductors. Steam boilers, pipes, etc., are frequently packed in asbestos or coated with non-conducting materials in order to retain the heat and save expenditure of fuel.

Heating by conduction may readily be wasteful, as it may pass through improperly constructed walls to the cold outer air, where it is lost.

2. *Radiation.*—All bodies surrounded by transparent substances are continually radiating heat, which may be absorbed, transmitted, or reflected in the same way as light. Light is, in fact, a form of radiation which is visible.

The amount of heat radiated per second depends upon the temperature in some way not yet understood. Polished surfaces of hot substances radiate less heat than dull surfaces; good reflectors are bad radiators. Good radiators are good absorbers; transparent bodies are bad radiators, *e.g.*, a glass screen in front of an open fire.

Radiation falling on a polished surface such as steel

is reflected; but if the surface is dulled with lampblack, the heat is absorbed. Hence the reason for polished steel surfaces round an open fire, as heat is reflected from the steel and not absorbed, to be afterwards radiated. If the surface be dull white, the heat is diffusely reflected in all directions. Thus the reflection of sunlight from a snow field may cause the same effect as if the surface of the snow were hot. This causes sunburn in the high mountains where there is sunlight on the snow.

3. *Convection.*—Convection refers to the currents set up by the differing temperatures of portions of air caused by contact with heated bodies—the hotter air rising and the colder air falling. Air in contact with a hot surface is heated by conduction, and then becomes specifically lighter than the cooler portions. The heated air then rises, being pushed upwards by the sinking of the colder air. Convection currents are very complicated in a closed room. The heat of the open fire crosses the room in direct lines to the walls, furniture, etc., without materially heating the air itself. The surfaces of the walls and furniture absorb this radiated heat and communicate it to the air by conduction, and thus form other convection currents upward. Heat may be reflected from polished surfaces to absorbent surfaces in other parts of the room, and cause by conduction to the air further convection currents

Windows being colder than the air in contact with them, may cause downward convection currents, whilst the sun rays falling on wall or furniture cause upward convection currents. The convection of air by the

draught up the chimney still further complicates the currents of air. By watching the motes in a sunbeam in such a room the air is shown to be in a state of turmoil.

The human body in an atmosphere colder than itself causes convection currents, thus supplying a certain amount of fresh air to the body. In hot climates this convection is lessened, and the necessity for punkahs and other artificial current formers is shown.

Smell is chiefly distributed by convection, and strong smelling substances may be used to show the rapidity of the currents of air. Smoke from a cigar will show the direction of these currents.

The convection of heat in liquids is made use of in warming by hot-water pipes, the currents set up in the water in the pipes from the boiler to the rooms being similar to those described in the air.

The cooling of a hot body surrounded by cooler ones depends upon a variety of conditions.

An iron room painted dead black would be very cold on a cold night and very hot in the sun's rays; whereas a house of brick (specific heat high) with a layer of air between double walls, painted white on the outside, with a thatched roof and double glass windows, would be warm in cold weather and cool in summer.

Economy of fuel is effected in houses properly built. Only sufficient heat should go up the chimney to ensure ventilation. Chimneys should be in the centre of the house, so that the heat should not be lost by conduction through the outside wall. Walls should be dry, as every pound of water from a damp wall means the consumption

of a pound of coal in an ordinary grate. Lighting gas to dry a room is not efficacious unless ventilation is provided to carry off the heated air containing the moisture; otherwise it would only be redeposited when the gas was turned out and the air cooled.

Walls should be thick, or double, and shutters to windows will keep the house warmer at night. But if the present indirect means of ventilation are closed it will be necessary to provide proper inlets.

It should be remembered that though loss of heat by radiation and convection help ventilation the loss of heat by conduction does not assist in any way.

VENTILATION.—By ventilation is meant the replacement of vitiated air by fresh air. Air is a mixture of gases, and fresh air may be said to contain 20·96 per cent. by volume of oxygen, 79 per cent. of nitrogen, and ·04 per cent. of carbonic acid gas, aqueous vapour 5 grains to 20 grains per cubic foot of air, small traces of ozone, and minute quantities of gaseous impurities. There will also be solid particles in suspension derived from the soil and the vegetable world. The weight of air varies according to barometric pressure and temperature. The lower the barometer, the less is the density or weight of the air.

Barometric pressure may be lowered by ordinary atmospheric changes, or by difference in altitude, as in a balloon or up a mountain. Whilst pressure remains equal, the density is decreased by a rise of temperature. For every degree F. of rise in temperature, the volume of the air is increased by $\frac{1}{491}$ of its volume at 32 deg. F. Air may also be cooled by reduction of

pressure, and use of this law is made in cooling chambers where by the release of compressed air a cool atmosphere is obtained.

The *carbonic acid gas* in the atmosphere has been shown to be ·04 per cent., or four parts per 10,000; when this is raised to six parts by the introduction of organic impurities of respiration, the limit of impurity is said to be reached. That this is a desirable standard is evident, but sanitarians will often have to be content with a larger amount of impurity. This impurity must not be confused with the amount of CO_2 arising from products of combustion.

In order to sufficiently dilute this added impurity, it is necessary to introduce 3,000 cubic feet of fresh air for each person per hour. It has been suggested that instead of six parts per 10,000 as the standard of impurity, ten parts should be adopted for towns and thirteen parts for schools, with an additional test showing that there are not more than twenty microbes per litre of air.

Dust is always present in air except on the tops of high mountains and at sea. The solid particles vary in number, but they are capable of carrying microbes and assisting in the spread of diseases. Dust remains in suspension from the convection of air currents. When the air is still, it is deposited, or even when flowing very slowly it settles on horizontal flat dry surfaces. From wet surfaces there is constant evaporation in which the smaller molecules of water bombard the larger particles of suspended dust which are then carried further away by the current of air. A somewhat similar result follows when cold air containing dust is passing over warmer

surfaces, as the cold molecules, touching the hot surface, rebound with greater force than they strike. It is to this repellant action of moist and warm surfaces that dust laden air passing into our bronchial tubes is driven out again, with only a partial deposit of the microbe-carrying dust. The reverse effect takes place if the surface is cold and the air warmer. The deposit of soot in a chimney and of dust on walls near hot-water pipes is explained in this way. Air containing the dust or soot is warm and the particles are deposited on the cold wall.

Air filters should be colder than the air passing through them, for the same reason. Jute cloth screens, 17 ft. by 4 ft. collected 2½ lbs. of dust in seven weeks in University College, Dundee. All conduits for air should be so arranged that they can be readily cleaned.

CHAPTER X.

METHODS OF VENTILATING, ETC.—Variation of barometric pressure; air of differing densities; currents.—Fall of barometer or rise in temperature; air heavier; volume requires larger space.—Direct impact of wind; open door or window.— Wind blowing across an opening; release of pressure.—Up-draught; cowls; smoky chimneys; steam jet.— Ventilation by fans.—Circular fans.—Natural ventilation and mechanical.—Organic impurity.—Vacuum and plenum systems.—Relative exposure.—Difficulties of ventilation in lofty buildings.—Death rates in crowded tenements.—Air space per head.—Air entering a room from a tube.—Natural ventilation.—Outlets high.—Fresh air should not cause draught.—Window with bottom board.—Tobin's ventilators.—Louvre windows.—Ventilating fireplaces.—Perforated bricks.—Sherringham's ventilator. — Cornices. — McKinnell. — Tubes over gas burners.— Size of openings.— Outlets smaller than inlets.—Filtered air.—Gas lights.—Increased ventilation.—Advantages of electric glow-lamps: no impurity; no absorption of oxygen.—Chimneys—Uptakes in winter, downtakes in summer.—Cubic capacity per head.—Measurements of cubic capacity.—Temperature.—Floor space.—Board of Education requirements too low.—Cleaning schoolrooms.—Blow through.—Open fire radiation— Closed stoves.— Impure gases.— Cast iron.—Carbon monoxide; danger to life.—Gas stoves.—Hot air.—Hot water.— Low pressure.— High pressure.— Steam pipes.— Protection to pipes.— SUMMARY.— EFFECTS OF OVERCROWDING.—Headache.— Thirst.— Rise of temperature.—Death.—Black Hole.—Tubercle bacillus: destroyed by sunshine; spread by dust; spread of infectious diseases.—Sewer air.—Typhoid.—Pneumonia.—DRAINAGE.—Straight lines.—Automatic flushing.—Inspection.

Ventilation.—The displacement of foul air may be brought about in different ways.

1. VARIATION OF BAROMETRIC PRESSURE AND OF TEMPERATURE.—This causes intermittent ventilation, air of

different densities causing currents. Thus, equilibrium is disturbed, and what is known as a "head" is formed.

(*a*) A fall of 1 inch of the barometer always follows the abstraction of 57 cubic inches of air from every cubic foot, or about $\frac{1}{30}$ of its bulk. The lowering of the barometer is caused by a decrease in the density or weight of the air; a given weight of air occupies a larger space, *i.e.*, a given volume of air weighs less.

(*b*) A rise in temperature of 1 deg. F. causes the expulsion of $3\frac{1}{2}$ cu. in. from each cubic foot, because the volume of 1 cu. ft. is increased $\frac{1}{491}$ part for the rise of each degree of temperature.

2. Direct Impact of Wind upon an Opening.—This is the simplest form of ventilation, and is best shown when doors and windows are open and there is a thorough draught.

3. Wind Blowing across the Opening of a Tube, Pipe, etc.—This causes a lessening of the amount of pressure at the end of the tube, and a sucking action is set up, which draws out the air from within. This often assists the draught up a chimney, and acts in a limited degree when the wind is blown past an open window or door. Cowls of various shapes are sometimes put on the top of ventilating pipes to increase the up-take or prevent down-draught. The pressure of the wind at the top of a smoky chimney is probably not the only cause of down draught; the pressure at the other end of the ventilating system is partly responsible. The draught in a pipe is sometimes assisted by the discharge of a steam jet along the tube in the direction in which the current is desired.

4. Ventilation by Fans—A number of vanes are attached to an axle. When the fan rotates, the particles of air slip along the vanes on the tips, and leave the tips at a tangent, at almost as great a velocity as that of the tips themselves. The motion of the air is from the centre to the periphery. The pressure at the axis is diminished. To obtain the full effect of the fan, it must be enclosed in a circular box with arrangement for the supply of fresh air at the axis, and for delivery by a tube from the circumference.

5. Ventilation by Bellows or Blowing Machines. —These are sometimes used instead of fans. It has been shown that in naturally ventilated schools the respiratory impurity shown as carbonic acid gas (carbon dioxide) is 15 to 18 per 10,000, whereas with mechanical ventilation it is only 11 to 12·5 per 10,000.

6. The Plenum and Vacuum Systems.—Reference is sometimes made to the "plenum" and to the "vacuum" systems of ventilation. The practical distinction is that in the "plenum" system the air is forced into the air conduits and escapes by chinks and crevices or by special exit ventilators, whereas in the "vacuum" system the foul air is drawn out and the fresh air enters by chinks and crevices or suitable openings. In some experiments conducted by me some years ago in H.M.S. *Polyphemus*, a torpedo ram, with the greater part of the hull under water, it was shown that the "vacuum" system was much more effective, the atmosphere of the lower deck when the men were asleep being much purer than when the "plenum" system was working. When the ship was under steam both systems

were kept at work, but the exhaust fans were much more expensive to work when in harbour, as special engines had to be kept going.

Where space is too great, difficulties may arise from the imperfect circulation of the air. Persons have suffered from breathing organic impurities given off by a crowd in a lofty tent, when, although the air space was large, there was no circulation of air from the upper parts of the tent to relieve the suffering humanity in the crowd. This difficulty seems to have been overcome in a church in Berlin, in which the air of the dome is kept at a higher temperature than the rest of the church, where pure air is maintained constantly (at 60 deg. F.) by natural ventilation. In small tenements the air is often very foul; the greater the number of rooms available, the less is the amount of impurity. Children suffer most, the death rate in one-roomed tenements being double what it is in four-roomed ones.

Each person should be allowed 1,000 cu. ft. of air-space, and provision should be made to renew the supply three times every hour, as 1,000 cu. ft. is rendered impure by the air expired from the lungs in twenty minutes, and thus becomes poisonous. This amount of cubic space (1,000 cu. ft.) is, however, rarely obtainable. In barracks 600 is allowed, in common lodging-houses 300, and in schools the Board of Education require 80 cu. ft. as a minimum. The objection to change of air is usually its chilling effects. This can be obviated by warming the incoming fresh air.

It must be borne in mind that ventilating shafts should be straight. Every bend or angle in a tube

diminishes the velocity. Angles obstruct the currents more than curved bends. Air entering from a tube is diffused more widely if the velocity is greater, but is more unpleasantly felt than a lesser velocity, which may penetrate further but less diffusively. The velocity is rapidly reduced as it leaves the tube. At the orifice the current is like the rapids of a river, but the stream quickly assumes the character of still flowing water.

INLETS AND OUTLETS.—Inlet ventilation causes more perceptible currents around the openings than outlet ventilation. In natural ventilation it is advisable to arrange the outlet at the highest point, since the expired air, being moist and warm, is lighter, and ascends to the upper parts of the room. Fresh air inlets should be arranged so as to avoid draughts. This is done by many devices. The lower window sash may be raised a little, so that the air enters between the lower and the upper sash, and is directed upwards. The air being colder and heavier than the indoor air, immediately falls, but the change in the direction of the current lessens the force of the draught. A board may be placed across the bottom opening of the lower sash, so that air does not enter there. If the difference between the internal and external air is more than 20 deg. F., a draught is felt.

Tobin's Ventilator is similar in action. An opening in the wall on the floor level is connected with a tube rising to a convenient height, usually about four or five feet, where the fresh air emerges without creating much draught. If the tube is made of metal, the incoming air is easily warmed by hot water, etc.

Louvred Panes of glass are sometimes inserted in windows with similar results.

Ventilating Fireplaces have a hot-air chamber at the back of the grate, through which air is conducted, and then warmed before being introduced into the room.

Perforated Bricks cause little draught.

Sherringham's Ventilator is a small vertical flap-door in the wall near the ceiling, balanced by a counterpoise, and hinged below so as to fall forward towards the room. It is cased in at the sides, so that the current is directed upward by the angle of the flap.

Ventilated Cornices have been made. The upper part may be used as an outlet and the lower as an inlet, or the cornices on different sides of the room may be outlets or inlets.

McKinnell's Ventilator consists of a smaller tube within a larger. Fresh air enters between the two tubes, and is deflected by a flange upon the inner tube, which acts as an outlet. The sectional area of the inner or outlet tubes is the same as that of the inlet.

An opening is sometimes made from the room into *the chimney*, back draught being prevented by lightly moving flaps, which close by their own weight in the absence of an upward current. *Tubes over gas lights* are also used to carry off vitiated air. An inner tube is arranged to carry off the products of the burning gas; this passes at a suitable point into a larger tube, and the vitiated air is carried away by the heat of the space between the two tubes.

The size of the openings should be about 24 sq. in. per head for outlet, and 48 sq. in. for inlet, but no single

outlet should exceed 60 sq. in. or inlet 144 sq. in. if undue draught is to be avoided.

Air should be taken from suitable points free from contamination of drains, smoke, etc., and, if necessary, it may first be warmed and filtered before being introduced.

When there is only one opening in a room this may act both for inlet and outlet, and many ventilators will act sometimes as inlets, sometimes as outlets, according to the atmospheric conditions.

In winter, in rooms warmed by open fires streams of warm air ascend to the ceiling from the more central parts of the apartment, whilst sheets of colder air slide down the walls and windows. Just as in some streams warm water flows for a long distance above a colder layer, so air at different temperatures does not mix as readily as might be expected.

Stinking gases such as hydric sulphide (sulphuretted hydrogen) if a little warmer than the air in the room, though making the air slightly denser do not sink like cold air, but rise and diffuse rapidly.

Gas jets burning in a room should be provided with special outlets to carry off the impurities of combustion, such as carbon di-oxide and sulphur dioxide, etc. It is computed that 1,800 cu. ft. of fresh air should be introduced for each cubic foot of gas burned. Note, however, that the carbon di-oxide from gas has a less relative impurity than that from the lungs.

Incandescent Electric Lamps cause no impurity and absorb no oxygen, as the filament glows in a vacuum within the glass bulb. The heat developed is less than

that given off by a man or a candle, and about one-tenth of that from an ordinary gas jet.

In winter the *chimneys* if not placed in thin external walls, even when fires are not lighted, are warmer than other parts of the house, and they act as outlets, but in summer the walls are warmed by the sun and with open windows there is often a downcast from the internal chimneys. A gas jet is sometimes burnt in the chimney to remedy this, or an electric fan will set up a draught where the current is available. The amount of fresh air required per hour averages 3,000 cu. ft. per person.

9,800 cu. ft.	is required	per adult	male	in hard work.
4,750	,,	,,	,,	,,	light work.
3,600	,,	,,	,,	,,	in repose.
3,000	,,	,,	,,	female	,,
2,000	,,	,,	child in repose.		

MEASUREMENTS OF AREAS.

Area of a circle	= $D^2 \times \cdot7854$
,, ,, ,, ...	= $C^2 \times \cdot0796$
Circumference of a circle	= $D \times 3\cdot1416$
Diameter of a circle ...	= $C \div 3\cdot1416$
Area of an ellipse ...	= Product of the two diameters $\times \cdot7854$
Area of parallelogram ...	= Base $\times$ vertical height
Area of triangle	= Base $\times$ half height, or height $\times$ half base

Irregular spaces must be divided up into parallograms, triangles, etc. The cubic capacity of a room is the area of the floor space multiplied by the height.

The temperature of class rooms should be kept at from 60 deg. F. to 65 deg. F. In the infants' department 65 deg. F. is more suitable. The Board of Education has made 80 cu. ft. the minimum air space per child with 8 sq. ft. as the minimum floor space. Under the London

School Board older children have about 10 sq. ft. of floor space. It is practically impossible under these conditions to maintain the maximum impurity at 6 parts per 10,000 carbon di-oxide, and 10 parts are frequently present, external air having 4 parts. Even then in a room 10 ft. high it would be necessary to change the air about fifteen times per hour. In order to avoid the feeling of draught, it would therefore be necessary that the incoming air should be warmed.

PERFLATION.—The school-room should be cleared from time to time, and a thorough blow through obtained by opening the windows and doors, unless special artificial arrangements are provided for ventilation.

Warming.—OPEN GRATES.—With an open fire nine-tenths of the heat of combustion disappears. A part is carried away with the products of combustion, and a part disappears by conduction through the walls, while much of the fuel itself is wasted, passing up the chimney in the form of soot. The heat taken by conduction to the walls has very little heating effect upon the air by convection currents as from the situation of the fire bricks, etc., it is clear that the air heated by passing over them is carried up the chimney by the strong draught. The heating effect of an open fire is therefore chiefly by radiation. Fire brick should enter into the construction of the grate more than iron, as it is a better radiator. A narrowing of the chimney opening to prevent too great an escape up the chimney is one means of economising heat. Air chambers behind the grates are often introduced with good effect.

Closed Stoves.—These are very economical in the production of heat, but they do not remove enough air. There is often a feeling that the air is burnt, and there is over-dryness. Whether this latter feeling is not due to gases given off from the closed stoves, and especially through joints, etc., is not clearly known. Carbonic oxide is found to be present when cast-iron stoves are used, but not so much with wrought-iron. Red hot cast-iron reduces carbonic acid (carbon dioxide) to carbonic oxide (carbon monoxide). Wrought-iron does not do this so readily.

Gas Stoves.—These are convenient but expensive, especially for warming large rooms. Care must be taken to carry off the products of combustion which, besides water vapour and carbon dioxide, include coal gas and a certain amount of sulphur dioxide derived from the carbon bisulphide and sulphuretted hydrogen which occur as impurities. Now that water gas is being used to cheapen coal gas, carbon monoxide is also liable to escape. This gas being odourless may be breathed unwittingly with fatal results. Heating by hot air can only be effected for a short distance, as the amount of heat carried by a given quantity of air is small. One of the best methods is to pass the air through chambers containing hot water pipes, and thence into the room to be ventilated.

Hot Air Furnaces.—Heating from a central hot-air furnace is sometimes unsatisfactory, unless attention is paid to the details. The heating chamber should not be remote, otherwise the air must be unduly heated; and the furnace should be large, otherwise in cold weather

noxious gases such as carbon monoxide, etc., will be produced by the great heat employed and sent with the air into the rooms.

Cool air should be mixed with the hot air as required. If the hot air supply is cut off from the room, the inmates breathe the impure air over and over again, unless alternative openings are provided to give natural ventilation when the artificial supply is stopped. The source of air supply must be good, and the furnace-room should be well supplied with fresh air.

Hot Water Pipes.—Heating by hot water pipes is convenient. Air passing over hot water pipes is not usually raised above 100 deg. F., even when the temperature of the pipes is much higher. With low-pressure there is a somewhat higher first cost on account of the large size of the pipes. Heating by high-pressure is less costly to initiate as the pipes are smaller. The weakest part is in the coil of pipe in the fire, and there a burst would be most likely to occur. Such bursts do not appear to be as dangerous as in low-pressure boilers. Hot water continues to circulate through the pipes after the fires are put out, more particularly with low-pressure systems. Heating by steam pipes is used abroad but is not much employed in this country; the tending to the boiler must be continuous to keep a head of steam, and is therefore expensive. In *Perkins' System* strong pipes, hermetically sealed, contain a measured amount of water. This is generated into steam, and thus expands to fill the whole system of pipes. It cannot escape, and when the fire goes out the steam condenses to water.

Hot pipes should be protected as burns may be caused to young children, etc.

Summary.—MECHANICAL VENTILATION.—Gives more constant purity and is independent of weather; schools are warmer and less draughty; equal distribution of heat and fresh air; diminution in the number of micro-organisms; first and annual cost very heavy.

OPEN FIRES.—Cheerful, air fresher, paint work lasts longer; first cost less, but upkeep more than stoves or pipes; air said to be more charged with micro-organisms than with hot pipes.

STOVES.—Small first cost, but not cheerful, and often cause disagreeable dryness of atmosphere.

HOT PIPES.—Less annual cost; equal distribution of heat; first cost heavy; high-pressure pipes cheaper than low-pressure; atmosphere purer; air not as fresh as with open fires.

Effects of Overcrowding.—The effects of fœtid air containing organic matter, excess of water and carbonic dioxide produced by respiration are headache, heaviness, inertness, and occasionally faintness or nausea. The organic matter is the most poisonous, as has been shown by experiments, when the watery vapour and the carbon dioxide were removed. Persons kept in such an atmosphere have an increased temperature, quick pulse, loss of appetite, dryness of mouth and thirst. When the overcrowding is very great, as in the Black Hole of Calcutta, death ensues. Of 300 Austrians imprisoned in a small room after the Battle of Austerlitz, 260 died.

When people have to live in a moderately vitiated atmosphere, the aeration of the blood seems to be interfered with, and the general tone of the system is impaired. Persons become pale, and lose appetite, strength and spirits. Such persons are more liable to pulmonary complaints, and consumption is a disease frequently occurring amongst them. This has been brought to the public notice very forcibly of late years, the discovery of the tubercle bacillus having shown the way in which Consumption is spread in foul air. The tubercle bacillus is destroyed by sunshine and in fresh air. It is carried into the lungs on the particles of dust. It has been shown how in healthy persons many germs may be thrown off, but if the person into whose air tubes the bacillus is introduced is suffering from poor health through confinement in vitiated air, the bacillus effects a lodgment and the disease known as phthisis or consumption contracted. The phlegm coughed up by the patient dries on the floor, and being converted into dust is breathed by other persons who contract the disease therefrom.

Impure air also greatly facilitates the spread of infectious diseases, such as typhus fever (formerly called gaol fever when our prisons were badly ventilated), plague, smallpox, erysipelas, scarlet fever, and measles.

Measles in particular, is greatly spread by overcrowding, and this is apparent when it is remembered that its great infectivity is in the earlier stages, when the symptoms are similar to those of a severe cold in the head.

Sickness of any kind is aggravated by treatment in

confined spaces, and many diseases have been treated more successfully in the open air than even in hospital.

Air rendered impure by combustion, though containing considerable amounts of carbon dioxide, is not so injurious as air containing carbon dioxide expired by human beings. Particles of coal, sulphur dioxide, and impurities of combustion have an irritating effect upon the lungs. Persons confined for long in such atmospheres suffer from headache, heaviness, and pallor.

Air rendered impure by emanations from sewers and drains may be very dangerous. The clearing out of a privy in a school caused violent purging, vomiting, great prostration and twitching of the muscles in many of the children. In small quantities these emanations may cause headache, loss of appetite, and generally impaired health. Sulphuretted hydrogen, sulphide of ammonia, and carbon dioxide are the gases that appear to cause the poisonous effects.

Amongst other diseases, typhoid fever and pneumonia are often thought to be caused by sewer gas. It is probable that such is the case, but direct proof is at present not available.

Water-closets should be divided from the school-rooms and passages by a lobby with cross ventilation. All drains should run outside the buildings—not under them. They should be in straight lines, and at every bend a man-hole, with air-tight cover, should be provided to give access for cleaning. The drain ventilators should be carried up the sides of the buildings in straight lines. The tops may be covered with a wire cage to prevent

access of birds, who sometimes block up unprotected pipes with their nests.

It is a good plan to have a large cistern at the head of the drainage system which is discharged automatically at stated intervals. The teacher should inspect the whole drainage system from time to time, to see that everything is working properly.

CHAPTER XI.

SCHOOL ACCIDENTS.—First Aid of St. John's Ambulance Association. — Contusions; black eye. — Abrasions. — Wounds.—Bleeding; arterial jets; venous bleeding.—Course of blood vessels.—Tourniquets.—Hæmorrhage from lungs and nose.—Concussion; unconsciousness for short time; quiet.—Fainting.—Fits.—Epileptic; danger of injury.—Hysterical; freedom from injury.—Stings of bees, wasps, etc —Bites of animals; binding of limb above the injury.—Choking; removal of obstruction.—Frost-bite; chilblains.—Burns and scalds; lying down, covering with rags, etc.—Corrosives; sulphuric acid.—Poisons; emetics.—Shock and collapse; after severe injuries. —Foreign bodies in nose and ears; not to be meddled with.—Foreign bodies in eye; removal.—Electric shock. —Artificial respiration.—Apparent drowning.—Broken bones; supporting the limb; danger of wound of skin; temporary splints.—Sprains; rest and cold.

First Aid.—Every school teacher should qualify in First Aid under the St. John's Ambulance Association. Under the auspices of this society there is published an emergency book on card to hang on the wall, giving simple directions for procedure in emergencies. Every school should be provided with something of this kind. In this chapter a few simple remedies are described, such as any person can apply whilst skilled aid is being fetched.

CONTUSIONS.—When the skin is not broken there may be rupture of small vessels beneath the skin, giving rise to swelling and discoloration, as in black eye. The swelling is brownish-red, becoming black, and after a few days green and yellow. If there is deep-seated

bruising, as from a sudden fall, the discoloration may not appear for some days. The application of brandy, etc., to the skin round a black eye may prevent discoloration. Cold compress, ice, and evaporating lotions are also useful.

Abrasion of the Skin.—Skin is often rubbed severely in falls, etc. There is not exactly bleeding, but the skin is reddened and raw-looking. Dirt and gravel, etc., should be washed away or removed with a clean dry rag. Friars' balsam or collodion may be applied, or a piece of clean wet rag. Avoid sticking plaster.

Wounds.—If the flesh is torn or cut a wound is caused. If there is slow oozing of blood when the wound is

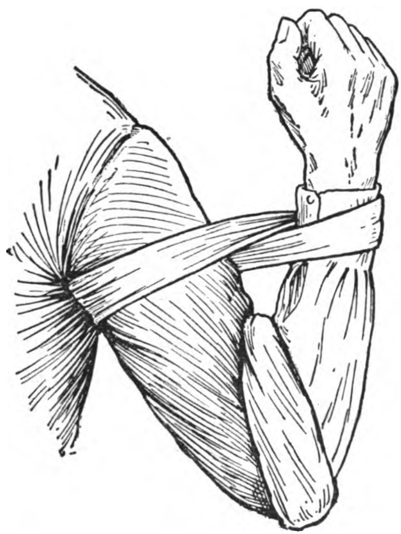

Fig. 21.—Bleeding at the Elbow.

cleansed, apply a clean dry rag and bind up. The blood

will clot and so stop further bleeding. The sides of the wound may be brought together by pads kept in place by a bandage. Sticking plaster should be avoided. If the blood spurts from the wound with the pulse beats an artery has been severed. A clean dry pad with pressure by a bandage will usually stop the hœmorrhage. The elevation of the wounded limb helps to lessen the strength of the blood current, and where practicable, flexing the limb at the joint above the wound will often

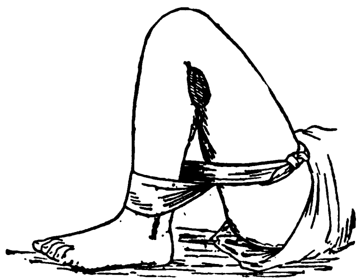

Fig. 22.—Bleeding at the Knee.

stop the bleeding. A pad in the bend of the elbow or behind the knee will press on the main blood vessel. The ankle may be secured to the thigh, or the wrist to the upper arm to keep the parts fixed as shown in the wood cuts. Bleeding from the palm may be controlled by putting a pad on the wound and closing the fist tightly, the closure being enforced by a bandage.

In *venous bleeding* the blood is dark purple, and wells slowly out of the wound. The patient should lie down, and the limb should be elevated, garters and other constrictions being removed. A dry pad of lint and a bandage will usually stop the bleeding.

The course of the large bloodvessels of the limbs may be roughly described.

The *main artery of the arm* may be felt in the armpit. It passes inside and behind the biceps muscle, coming in front of the flexure of the elbow joint. It then divides into two branches, the radial branch being felt at the wrist near the thumb.

The *main artery of the thigh* may be felt in front, just inside the mass of the extensor muscles. It passes obliquely towards the inner side of the knee and then behind, where it can be felt when the knee is flexed. It is not readily felt lower down.

A *tourniquet* for stopping the flow of blood in the large artery may be made by wrapping up a round stone or similar object in a handkerchief and applying this over the course of the bloodvessel above the wound, *i.e.*, on the side nearer the heart. The ends of the handkerchief should then be tied round the limb and a stick inserted between the knot and the limb. By turning the stick round, the band is tightened and the stone is pressed down on the artery. Braces, straps, etc., may be used to form the band of the tourniquet which, being brought over the stone, presses it down on the artery. A piece of indiarubber tubing turned several times round a limb and firmly fastened makes a good tourniquet.

Bleeding from the Lungs.—If bright red blood is coughed up it may come from the lungs. The patient should lie perfectly quiet and be given plenty of fresh air.

Bleeding from the Nose.—This is a common complaint in childhood. Let the child sit in a chair with

the head raised; unfasten tight clothing at the neck and apply cold compresses to the nose and nape of the neck. The arms may be raised above the head. If bleeding persists, syringe out the nose with cold water, and then plug the nostrils with a piece of clean lint or cotton wool. Give plenty of fresh air.

CONCUSSION.—In concussion there is loss of consciousness. This appears to be caused by the sudden mechanical shaking up of the brain substance without structural injury. The unconsciousness should not last many minutes unless there is structural injury. Vomiting often occurs as the patient is recovering. The symptoms of shock or collapse (p. 143) may be present more or less. The patient should be kept perfectly quiet (in bed if possible) in a darkened room, and the treatment should be continued for some time after recovery. The diet should be very sparing and simple.

FAINTING AND FITS.—In fainting, the patient turns pale, is restless and anxious, breaks out in a cold sweat, and loses consciousness. Give access to fresh air, loosen the clothing, and let the patient lie flat on the back with the head low. Smack the face and hands sharply with the end of a wet towel, and on returning to consciousness give a little tea or coffee.

Epileptic Fits occasionally occur in school life. The patient may give a scream, but not always, and fall unconscious. The limbs are twitched and jerked about convulsively, and the face is contorted, with, sometimes foaming from the lips. The teeth are clenched, and the tongue may be bitten. Loosen clothing and remove anything against which the patient might hurt

himself. Wrap up a penknife in a handkerchief and place between the teeth to prevent the tongue being bitten. Do not restrain the movements, and allow the patient to sleep after the fit. Neither food nor drink should be given.

Hysterical Fits are common in young girls. The patient howls and screams, kicks about, laughs and cries by turns. She does not hurt herself. Flick the face with a wet towel, avoiding the eyes. Send all friends out of the room, and make as little fuss as possible.

Stings of Bees, Wasps, &c.—Remove the sting, if possible, bathe with hot water, and apply a little solution of bicarbonate of soda or weak ammonia.

Bites from Animals.—Tie tightly a piece of string or a handkerchief round the limb above the bite. Wash the wound freely by putting it under the tap and allowing the full pressure of the water to fall on it. The wound may be sucked by a person whose mouth is free from cracks or sores.

Choking.—This is caused by the blocking of the wind pipe with articles of food, coins, etc. Put the forefinger down to the root of the tongue *boldly*, and try to hook up the obstruction. Pat the back to provoke coughing, if the symptoms are not very urgent.

Frostbite.—This is not very common in this country, but in severe winters the tips of the ears, nose, fingers, or toes may be slightly affected, exhibiting a greyish-white or tallow hue. Do not apply heat but soft snow or cold water till the circulation is restored.

Chilblains are more common in girls than boys, and most common when there is the debility of the patient.

When first coming on, the parts should be rubbed gently with snow or some cold material. A little soap liniment may then be used. The application of resin ointment and cotton wool protects the part from cold. Tonics and cod liver oil may be given.

Burns and Scalds.—*Flannellette is very inflammable.* When clothing catches fire the person should lie down and roll himself over and over. He should be covered with rugs, blankets, etc., or a coat, if nothing better is at hand. If a woman is attending to the person whose clothes are alight, she should fasten her skirts tightly about her to prevent them catching fire. As an application, equal parts of olive oil and lime water on rags is soothing, and the parts affected should be wrapped up in cotton wool. A saturated solution of bicarbonate of soda is also useful to relieve pain. In removing stockings, underclothing, etc., care should be taken not to tear the skin off where they adhere.

Corrosives.—Sulphuric acid, or vitriol, may be brought into contact with the skin through explosions in the chemical laboratory. The excess of the acid should first be rapidly removed with cotton wool or a clean *dry* cloth, as it is the combination of the acid with water, either of the body or applied externally, which causes the sudden development of heat and consequent burning of the tissues. As soon as the mass of corrosive liquid has been removed, the parts should be freely irrigated with water. Further treatment should be the same as for burns and scalds.

Poisons.—The kinds of poison most likely to be swallowed by school children are fungi, berries, etc.

An emetic should be given, to be followed by a dose of castor oil with 15 drops of laudanum, or less for a small child. To cause vomiting, tickle the back of the throat with the finger. A useful emetic is made by adding one tablespoonful of mustard powder to half a pint of lukewarm water. Atropine is an antidote to muscarine, the poison of many fungi, and a dose of 3 to 5 drops of *liquor atropiæ* may be given after the emetic has had effect, if medical aid is not within easy reach. If carbolic acid is taken, half an ounce of Epsom salts should be given after the emetic has had effect.

Shock or Collapse.—This always occurs with severe injuries. The face is pale, the surface of the body is cold, the pulse being weak and irregular. Respiration is feeble, the breathing being shallow. The patient is only semi-conscious. Keep the head low, and cover the body with warm clothing. Rub the limbs and apply hot water bottles to the body and extremities. Give warm drinks, and, if necessary, resort to artificial respiration.

Foreign Bodies in the Ears or Nose.—Do not attempt to remove them, but send for a doctor.

Foreign Bodies in the Eye.—Try and remove the substance with the corner of a handkerchief, a clean feather, or a clean soft paint brush. If the eye is too painful to allow this, drop in a little castor oil and apply a cold compress. If a noxious fluid has got into the eye, wash out with clean water. Do not rub the eye.

Electric Shocks.—The hands may be bruised and there may be some difficulty in letting go the wire. India-rubber is a non-conductor, and a tobacco pouch may be used to protect the hands of the person assisting

the patient. In serious cases artificial respiration should be resorted to.

ARTIFICIAL RESPIRATION.—The following is the procedure to be followed in inducing artificial respiration :—

i. Pull the tongue forward. An assistant should hold it in that position with a piece of cloth or a handkerchief. This is to prevent the root of the tongue falling over the windpipe.

ii. Raise and support the shoulders with a roll of clothing. Let the head lie low.

iii. Kneel down on both knees behind the patient's head, and grasp his arms just below the elbows; press the bent arms firmly against the sides and front of the chest (Fig. 23).

Fig. 23.—Artificial Respiration ; Expiration.

iv. Next slowly and steadily pull the arms upwards and outwards over the head till the elbows almost touch the ground (Fig. 24). This causes the lungs to expand and the air to rush in.

v. These movements (iii. and iv.) must be repeated alternately about fifteen times a minute until the patient

begins to breathe, or until hope is abandoned. Meanwhile, to excite respiration, smelling salts or snuff may be applied to the nostrils, and hot and cold water alternately may be dashed, in moderate amount, over the neck and head.

Fig. 24.—Artificial Respiration; Inspiration.

vi. When breathing is restored, the movements should be so regulated as to synchronise with the respiratory efforts of the patient. An assistant should then rub the arms and legs from below upwards to assist circulation of the blood.

vii. Remove wet clothing, cover with warm, dry clothes, and apply hot-water bottles to the feet, limbs, and body.

viii. Give stimulants as soon as the power of swallowing is restored.

ix. After prolonged unconsciousness or a sudden immersion the person should go to bed and remain quiet for some hours.

In the Apparently Drowned.—Turn the patient on his face, and put your finger down to the root of

his tongue, to clear out seaweed, etc. Then clasp him round the waist with your arm, and allow the water to drain out of his throat and lungs. Place him on his back, and immediately the air passages seem free of froth and water proceed to artificial respiration.

BROKEN BONES.—Cut away the clothes from the limb. Move the limb as little as possible, or the skin may be punctured by the end of the broken bone. If there is a wound, treat it as described before. If it is necessary to move the patient, support the limb both above and below the fracture, and gently place it as nearly as possible in the natural position. Support the limb with a temporary splint, such as an umbrella, or stick, or billiard cue. Wrap these in clothing for padding, and then fasten to the limb above and below the fracture by a handkerchief, necktie, etc., passed round the limb and the support. If the fracture is of the leg, fasten the sound limb to the broken one at knee and ankle. The straw cover of a wine bottle serves, as a good splint and padding combined, for the arm or ankle.

SPRAINS.—The joint should be kept at rest, cold compresses being applied and the limb elevated, so that blood may readily flow from the injured part.

Further directions for dealing with injuries may be obtained in the publications of the St. John Ambulance Association (St. John's Gate, Clerkenwell, London, E.C.), and in other works of a similar character. The "Emergency Book" previously referred to is

published at half-a-crown, and is to be obtained from the publishers, 83, Newman Street, London, W. The St. John Ambulance Association issue also an excellent little work at one shilling, on "First Aid to the Injured," and it is from the latter work that—by the courtesy of Lord Knutsford and the Executive Committee—we have been enabled to reproduce the diagrams illustrating this chapter.

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Printed by Henry Palmer & Co., *London.*